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CHAPTER 1

INTRODUCTION

Distance running is becoming an increasingly popular leisure-time activity among South Africans of diverse age, ethnic, and socioeconomic groups. Although maintaining an endurance training programme requires a disciplined, determined, and persistent approach, the rewards appear to be numerous and worthwhile. The sport not only provides a simple, affordable, and convenient form of physical exercise, it offers opportunities for social interaction, companionship, personal challenge, and a sense of mastery and accomplishment.

There is also considerable evidence to suggest that distance running affords significant physical and psychological health benefits. The following statement underscores the substantial value associated with engaging in regular physical activity: “If exercise were a new pill, it would no doubt be marketed with unprecedented vigour. In the emerging pandemic of the metabolic syndrome, exercise would be touted as the panacea which addresses every facet of the disorder” (La Gerche & Prior, 2007, p. S102).

Consistent with this view, a growing body of research suggests that habitual physical activity is associated with decreased coronary heart disease and lower cardiovascular disease mortality (Dubbert, 2002; Paffenberger, Hyde, Wing & Hsieh, 1986). Regular exercise may also reduce the risk of developing hypertension, non-insulin-dependent diabetes mellitus, colon cancer, and osteoporosis (Dubbert, 2002). Additionally, distance runners are likely to enjoy increased fatigue resistance, greater muscular strength and endurance, and better weight management (Landolfi, 2012). Important psychological benefits in relation to physical activity have also been documented. These include reduced stress, depression, and anxiety; heightened self-confidence and self-esteem; and improved emotional well-being, self-concept, self-efficacy, and stress management (Khatri & Blumenthal, 2007).

Defining Exercise and Related Terms

Exercise has been defined as structured and repetitive activity that is performed for the purpose of enhancing or maintaining physical fitness (Dubbert, 1992). Physical fitness, in turn, is “a dynamic state of energy and vitality that enables one to carry out daily tasks, to engage in active leisure-time pursuits, and to meet unforeseen emergencies without undue fatigue” (Khatri & Blumenthal, 2007, p. 983). Physical fitness comprises various dimensions, including cardiorespiratory fitness, body composition, muscular strength and endurance, and flexibility (Dubbert, 1992). The terms, exercise and physical activity are often used interchangeably (Dubbert, 1992). However, exercise can also be viewed as a subset of physical activity, which refers to any actions involving the skeletal muscles that increase energy expenditure (Dubbert, 1992).

Exercise can be classified on the basis of its frequency, duration, intensity, and energy source (Khatri & Blumenthal, 2007). According to sport and exercise scientists, athletic events can be placed into one of four categories: power events, speed events, endurance events, and ultra-endurance events (Hawley & Burke, 1998). Four different physiological power systems supply energy for each of these activities. The relative contribution of each system depends largely on the duration and intensity of an event. The four key power systems can be classified on the basis of whether they generate energy for muscle contraction in the presence of oxygen (aerobic power systems) or without oxygen (anaerobic power systems). The aerobic power systems consist of the aerobic glycolytic and aerobic lipolytic systems, while the anaerobic power systems are the ATP-CP (phosphagen) system and the anaerobic or oxygen-independent glycolytic systems.

Most competitive running events require energy from two major power systems, although the relative input of each system may differ (Hawley & Burke, 1998). For example, high-intensity sprinting lasting approximately 60 seconds is powered equally by the anaerobic and aerobic glycolytic systems. Conversely, the aerobic glycolytic system provides the primary source of energy for muscle metabolism in high-intensity endurance events lasting approximately 15 minutes to three-to-four hours. This suggests that energy for participation in most standard-distance races, from five kilometres to the marathon (i.e., 42.2 kilometres), is derived mainly from carbohydrate sources in the presence of oxygen. Longer-duration (i.e., longer than five hours) and less-intense ultra-endurance events, such as the Comrades Marathon, are powered predominantly by the aerobic lipolytic system. Exercise involving the large muscle groups that utilizes oxygen for its energy supply is often termed, aerobic exercise. Cardiorespiratory endurance or aerobic endurance refers to the ability to sustain aerobic activities, such as walking, running, swimming, and cycling, for an extended period

(Khatri & Blumenthal, 2007). The physiological requirements for endurance exercise include high aerobic power and resistance to fatigue (Hawley & Burke, 1998).

Health Risks of Distance Running

Despite the substantial advantages associated with an active versus sedentary lifestyle, paradoxically, exercise may sometimes have negative effects. For example, athletes like distance runners may be prone to musculoskeletal injuries (Khatri & Blumenthal, 2007; Noakes, 2001), and chronic or acute heavy exercise may increase susceptibility to upper respiratory tract infections (URTIs) (Nieman, 2001). Moreover, certain individuals may develop an unhealthy preoccupation with exercise that could be classified as a form of behavioural addiction (Berczik et al., 2012; Downs & Hausenblas, 2014; Khatri & Blumenthal, 2007).

Running Injuries

Defining a Running Injury

The word, injury, refers to "physical hurt" or "a specific instance of this: a leg injury" (*Collins English Dictionary*, 2006, p. 410). Therefore, a *running injury* may be defined as the occurrence of physical pain or discomfort involving the musculoskeletal system that is directly related to the activity of running. The term, musculoskeletal, in turn, refers to the skeleton and muscles of the body (*Dorland's Illustrated Medical Dictionary*, 1994). Another term for running injury is *overuse injury*, which refers to a disorder that is related to mechanical overloading of the musculoskeletal system (Lopes, Hespanhol, Yeung & Costa, 2012). Most running injuries may be described as intrinsic, which denotes a gradual onset and an internal origin (Noakes & Granger, 2003). Intrinsic injuries can be contrasted with extrinsic or traumatic injuries, which are caused by an external force or abnormal stress that results in immediate pain and disability (Grisogono, 1994; Noakes & Granger, 2003). Extrinsic injuries are more common in sports such as boxing, soccer, and rugby (Noakes & Granger, 2003).

Running injuries typically progress through several stages of severity and can become increasingly debilitating (Noakes, 2001). In the first phase, pain is usually experienced a few hours after exercise has ended. This is termed a grade 1 injury. A grade 2 injury is characterized by a sense of discomfort during running, but which is insufficient to affect training and race performance. During the third stage of injury, the level of pain experienced causes both a reduction in training and impaired athletic capacity. Finally, a grade 4 injury prevents any attempts at running (Noakes, 2001). Grisogono (1994) has described the progression of running injuries in terms of their duration, identifying an immediate, recent, and chronic phase. The immediate phase refers to the time the injury was sustained, while the recent phase describes the approximate two-week period following injury occurrence. Ultimately, the injury can be labelled chronic when it has lasted several weeks or months. Due to their gradual progression, running injuries are often not addressed until they become chronic and are more difficult to treat (Grisogono, 1994).

Prevalence of Running Injuries

Running injuries may be viewed as a preventable hazard of distance running. Eminent South African sport and exercise scientist, Tim Noakes (2001), has labelled the problem of overuse injury in runners, “the modern-day athletic pandemic” (Noakes, 2001, p. 973), citing injuries as a cause for concern. The running injury literature supports this perspective (Ekenman, Hassmen, Koivula, Rolf & Fellander-Tsai, 2001; Ellapen, Satyendra, Morris & van Heerden, 2013; Fields, Delaney & Hinkle, 1990; Hoffman & Krishnan, 2014; Johnston, Taunton, Lloyd-Smith & McKenzie, 2003; Lewis, Schwellnus & Sole, 2000; Noakes & Granger, 2003; Ryan, MacLean & Taunton, 2006; van Gent et al., 2007; van Middelkoop, Kolkman, van Ochten, Bierma-Zeinstra & Koes, 2008; van Poppel, de Koning, Verhagen & Scholten-Peeters, 2015). However, divergent estimates have been documented. Therefore, the precise extent of the injury problem among runners is uncertain.

The research literature suggests that between 50% and 70% of runners may sustain an injury resulting in lost training days every year (Lewis et al., 2000). For example, Hoffman and Krishnan (2014) found that 77% of a group of ultramarathon runners had been injured in the previous 12 months, 64% of whom were unable to train for at least one day due to injury. Other researchers have documented an annual running injury prevalence of 55% and 60%, respectively (van Middelkoop et al., 2008; van Poppel et al., 2015). However, somewhat lower and significantly higher injury estimates have also been reported. Fields et al. (1990) noted that 42% of runners in their study had been injured during the previous 12 months. In contrast, a recent South African investigation found that 90% of recreational half-marathon runners had sustained a running-related injury during the preceding year (Ellapen et al., 2013). In a systematic review of running injury research, van Gent et al. (2007) reported that runners' annual risk of developing an injury varied between 19.4% and 79.3%. Other reviewers have documented yearly injury incidence rates ranging from 11% to 85% (Nielsen, Buist, Sorensen, Lind & Rasmussen, 2012).

These discrepancies may be attributable to differences in injury definitions, study populations, and/or research designs (Lewis et al., 2000; Ryan et al., 2006). Due to the absence of a standardized definition, injury has been operationally defined as a reduction or stoppage in training for a specific period, missing a practice session or event, self-reported pain after exercise, or as self-determined (Ryan et al., 2006). Aside from variations in injury definitions, study populations have ranged from high school track and cross country runners, to novice 10 kilometre runners, and marathon entrants (Ryan et al., 2006, van Gent et al., 2007). As these groups are likely to differ in terms of age, experience, and training methods, it is feasible that their injury risk may also vary. Moreover, running injury research designs have included prospective and retrospective cohort studies, cross sectional studies, and randomised clinical trials (van Gent et al., 2007). Although the precise prevalence of running injuries may be unclear, it is evident that even conservative estimates place a significant number of runners at risk for injury every year.

Running injuries typically affect the lower extremities (van Gent et al., 2007). Research has consistently demonstrated that the main site of musculoskeletal injuries in runners is the knee (Ellapen et al., 2013; Noakes & Granger, 2003; Ryan et al., 2006; van Gent et al., 2007). In a systematic review of running injury research, van Gent et al. (2007) reported that other common injury sites were the shin, Achilles tendon, calf, heel, foot, hamstrings, thighs, and quadriceps. Less frequently observed injury locations were the ankle, hip/pelvis, and groin. While South African runners are also most likely to sustain a knee injury (Peters & Bateman, 1983; Ellapen et al., 2013), injuries involving the tibia/fibula and the lower back/hip are also quite common (Ellapen et al., 2013).

According to Noakes and Granger (2003), tendon-to-bone, and ligament-to-bone attachments seem to be most susceptible to damage as a consequence of distance running. Tendons are the elastic connections between muscles and bones, while ligaments are the non-elastic connections found between bones in a joint (Noakes & Granger, 2003). Bone injuries are also relatively common, while injuries to the muscles, tendons, bursae, blood vessels, and nerves may occur as well (Noakes & Granger, 2003). Ryan et al. (2006) reported that the five types of injuries seen most often at their clinic were patella femoral pain syndrome (formerly known as 'runner's knee'), iliotibial band friction syndrome (which also involves the knee), plantar fasciitis (which affects the base of the foot), meniscal injuries (which involve the cartilage discs in the knee), and medial tibial stress syndrome (also known as 'shin splints' or bone strain). In a systematic review of the literature, Lopes et al. (2012) found that the most frequently reported running injuries were medial tibial stress syndrome, Achilles tendonopathy (formerly Achilles tendonitis, which affects the tendon at the back of the ankle), and plantar fasciitis. Significant gender differences in injury type may occur (Ryan et al., 2006). For example, patella femoral pain syndrome and iliotibial band friction syndrome are more common among women, whereas plantar fasciitis and meniscal injuries are more frequently observed among men (Ryan et al., 2006).

Consequences of Running Injuries

Running injuries can have a significant negative impact on runners' psychological well-being. In this regard, Wiese-Bjornstal (2010) has stated that "sport injury occurrence in high intensity sport is an adverse and stressful health event associated with a complex multitude of risks, consequences and outcomes" (p. 103). Consistent with this view, it has been maintained that sport injury can profoundly affect participants' psychological health, leading to decreased self-esteem, and increased depression, anxiety, anger, tension, and fear (Pittsinger, Reese & Yang, 2013). Similarly, Noakes and Granger (2003) have argued that runners typically exhibit a negative pattern of response to injury that comprises sequential phases of denial, anger, depression, and ultimately, acceptance. Running injuries can also impair athletic performance (Grisogono, 1994) and cause training disruptions that may elicit unpleasant withdrawal symptoms (Allegre, Souville, Therme & Griffiths, 2006; Berczik et al., 2012). Other proposed adverse correlates and consequences of sport injury include pain, disability, social isolation, and an increased risk of developing future injury or degenerative disorders, such as osteoarthritis (Finnoff, 2012).

Upper Respiratory Tract Infections

Defining an Upper Respiratory Tract Infection

Upper respiratory tract infection is a nonspecific term that refers to infections involving the nasal passages, sinuses, pharynx, larynx, trachea, bronchi, and middle ear (Sucher, Sucher & Randall, 2010). URTIs include nonspecific infections such as the common cold, as well as sinusitis, pharyngitis, bronchitis, and otitis media (Sucher et al., 2010). Influenza is also described as an acute infection of the respiratory tract (*Dorland's Illustrated Medical Dictionary*, 1994).

The common cold has been defined as a mild catarrhal syndrome that is characterized by symptoms of nasal discharge and congestion, sneezing, sore throat, and cough or hoarseness (Gwaltney, 1979). Mild fever, watery eyes, headache, malaise, myalgia, and postnasal discharge may also occur (Sucher et al., 2010). Most colds are caused by the rhinovirus group (Gwaltney, 1979). Influenza also has a viral aetiology, and common symptoms include inflammation of the nasal mucosa, pharynx, and conjunctiva; headache; severe myalgia; fever; chills; and prostration. A necrotizing bronchitis and pneumonia may occur with severe influenza (*Dorland's Illustrated Medical Dictionary*, 1994).

URTIs like pharyngitis, an inflammation of the pharynx, and acute laryngitis, an inflammation of the larynx, usually occur in association with the common cold and influenza syndromes (Gwaltney, 1979). However, 5% to 10% of cases of acute pharyngitis in adults are diagnosed as 'strep throat', which has a distinct bacterial aetiology. Symptoms of this condition include sudden onset of sore throat, severe pain on swallowing, and fever (Sucher et al., 2010).

In a few cases, colds may lead to secondary bacterial infections of the sinuses and middle ear (Gwaltney, 1979). However, acute sinusitis, which is an inflammation of the paranasal sinus mucosa, is usually caused by a virus, and only prolonged and severe cases are likely to have a bacterial aetiology (Sucher et al., 2010). Symptoms of sinusitis include nasal discharge and congestion, facial pain or pressure, postnasal discharge, cough, and ear pressure or fullness (Sucher et al., 2010). Infections of the middle ear, known as otitis media, which mainly affect infants and children, may be caused by viruses or bacteria (Sucher et al., 2010).

The condition of bronchitis involves inflammation of the large airways of the lungs and typically presents as a cough. Acute bronchitis, which is mainly caused by a virus, affects about 5% of adults each year, with infections increasing during autumn and winter (Sucher et al., 2010). Coughing can persist for weeks following the acute phase of infection (Sucher et al., 2010).

The treatment for URTIs generally depends on the cause. For instance, antibiotics should be reserved for the treatment of infections that have a bacterial aetiology. Where viruses are the cause, only supportive agents are required (Sucher et al., 2010). These include bed rest, decongestants, analgesics, antipyretics, and fluids, as appropriate (Sucher et al., 2010).

Incidence of Upper Respiratory Tract Infections

The average adult typically experiences two to four common cold infections each year, although children may have twice as many infectious episodes during the same period (Gwaltney, 1979). People usually contract fewer colds as they grow older as advancing age is associated with acquired tolerance to previously-experienced viruses (Gwaltney, 1979).

It has been reported that distance runners should experience a low-to-moderate risk of contracting a URTI during regular training (Nieman, 2001). In support of this, one study found that recreational runners experienced a rate of 1.2 URTIs per person per year, which was considerably lower than the URTI incidence documented in three previous studies conducted in the general population (Heath et al., 1991). Further, several descriptive surveys have reported a lower-than-average actual or perceived risk of upper respiratory infectious episodes among distance runners and other endurance event participants (Nieman et al., 1993; Nieman, 1997; Shephard, Kavangh, Mertens, Qureshi & Clark, 1995). On the downside, however, runners may be more susceptible to URTIs during periods of heavy training and following intense, prolonged competition (Nieman, 2001).

Consequences of Upper Respiratory Tract Infections

The occurrence of an upper respiratory infection in a distance runner may be deleterious from several perspectives. For example, URTIs may have an adverse impact on health-related quality of life (Linder & Singer, 2003). Infections like colds and influenza can also disrupt training schedules and impair athletic performance (Nieman, 2001). Runners who continue to train hard or compete during a viral illness may experience more severe and persistent symptoms (Nieman, 2001; Shephard & Shek, 1999; Weidner & Sevier, 1996). Additionally, heavy exercise during an infectious episode may increase the athlete's risk of viral myocarditis, leading to possible cardiac arrest and sudden death during exercise (Noakes, 2001; Shephard & Shek, 1999). Consequently, clinicians have recommended that runners refrain from intense exertion when experiencing symptoms of the common cold and only resume normal training a few days after symptoms have disappeared (Nieman, 2000). However, if there is systemic involvement, as indicated by the presence of a fever, muscle aches, and swollen lymph glands, among other signs and symptoms, then intensive training should only be resumed after a few weeks (Nieman, 2000). In some cases, a URTI could lead to a prolonged, incapacitating state known as post-viral fatigue syndrome, which is characterized by myalgia, fatigue, and lethargy (Nieman, 2000).

Overtraining, Running Injuries, and URTIs

A variety of personal and environmental variables may interact to influence distance runners' susceptibility to disorders like overuse injuries and upper respiratory tract infections (Noakes, 2001; Wiese-Bjornstal, 2010). Training-related behaviours may be important modifiable risk factors in this regard (Appaneal & Perna, 2014; Gotovtseva, Surkina & Uchakin, 1998; Mackinnon, 2000; Nielsen et al., 2012; Nieman, 2001; Noakes, 2001). An understanding of the concept of overtraining may provide insight into how training-related variables could increase injury and infectious illness risk in runners.

Defining Overtraining

Overtraining may be conceptualized as a process of short-term excessive exercise training (Mackinnon, 2000). Also referred to as overload training (Keizer, 1998) or functional overreaching (Meeusen et al., 2010), this training strategy can lead to performance enhancements (Keizer, 1998; Meeusen et al., 2010). The athletic tradition of overreaching/overtraining is based on the overload principle, which states that habitual exposure to a stressor (i.e., physical training) will eventually result in adaptation to that stimulus or demand. When habituation has been achieved, progressively increasing the intensity, volume, and/or frequency of training will result in further performance improvements (Hawley & Burke, 1998).

However, the practice of overtraining can be a double-edged sword. All stressors, regardless of their source, elicit the secretion of neurohormonal substances that can impair the functioning of the immune system (Appaneal & Perna, 2014; Clow, 2001; Gotovtseva et al., 1998). According to the ‘open window’ theory of exercise and infection, transient immunosuppression may provide pathogens with an opportunity to invade the system, thus increasing the risk of developing viral infections (Nieman, 2001). If individuals undertake a new bout of intense exercise before their immune systems have recovered, then chronic immunosuppression may result (Pedersen, Rohde & Zacho, 1996). Moreover, prolonged, exercise-induced cortisol elevations in the bloodstream may impede skeletal muscle growth and tissue repair mechanisms following acute intense exercise (Appaneal & Perna, 2014). This may, in turn, have implications for running injury risk.

Furthermore, if athletes continue heavy endurance training for an extended period and fail to strike an optimal balance between the training stimulus and rest or recovery, they may develop a condition called the overtraining syndrome (Adams & Kirkby, 2001; Kellmann & Altfeld, 2014a; Mackinnon, 2000; Meeusen et al., 2010). This disorder has also been described as staleness or burnout (Mackinnon, 2000). The overtraining syndrome refers to an incapacitating state marked by impaired performance; chronic fatigue; psychological, hormonal, and immunological disturbance; and increased susceptibility to overuse injuries and infectious illness (Adams & Kirkby, 2001; Meehan, Bull & James, 2002; Kellmann & Altfeld, 2014a; Mackinnon, 2000; McKenzie, 1999; Meeusen et al., 2010). The main contributing factors include lack of programmed recovery periods, sudden increases in training volume and/or intensity, excessive race participation, monotony of training, and high levels of psychological stress (Mackinnon, 2000). It has been estimated that up to 65% of all distance runners may develop the overtraining syndrome (McKenzie, 1999), while between 7% and 20% of athletes may display symptoms of the disorder at any given time (Mackinnon, 2000).

Therefore, it is evident that either short- or long-term exposure to intense physical training stress could potentially have harmful physical health consequences. In other words, acute and/or chronic heavy exercise may increase the runner's susceptibility to musculoskeletal injuries and URTIs. A more detailed discussion of these ideas will be provided in Chapter 2.

Exercise Addiction

The concept of *exercise addiction* refers to the psychological or qualitative dimension of potentially harmful exercise behaviour (Adkins & Keel, 2005). The quality of physical activity engagement should be distinguished from quantitative aspects of exercise. For example, quantitatively unhealthy exercise can be established on the basis of observable training characteristics, such as the duration, frequency, and/or intensity of workouts (Adkins & Keel, 2005). However, qualitatively detrimental exercise behaviour describes exercise that is compulsive in character and associated with various maladaptive emotions, cognitions, and behaviours. These include rigid exercise patterns, negative emotional responses to training disruptions, and a focus on exercise to the exclusion of other commitments and activities (Adkins & Keel, 2005).

Although the two dimensions of exercise behaviour are likely to be related, qualitatively unhealthy exercise cannot be determined on the basis of the quantity of exercise undertaken (Adkins & Keel, 2005). For instance, individuals may follow a high-volume, high-frequency, and/or high-intensity exercise schedule but demonstrate flexibility in their approach. The exercise patterns of elite athletes could serve as a case in point. The finding that only about 20% of high-frequency exercisers could be classified as being at risk for exercise addiction (Cox & Orford, 2004) suggests that most individuals who train at high levels engage with exercise in psychologically healthy ways. Similarly, a person may exercise on a compulsive basis yet still undertake a healthy amount of exercise (Adkins & Keel, 2005). Nevertheless, it is probable that most compulsive exercisers will be inclined to over extend themselves – with possible adverse consequences (Hausenblas & Downs, 2002b). An important distinction between the two exercise dimensions pertains to their relation to psychopathology. Specifically, compulsive forms of exercise imply pathology by definition, whereas an excessive volume of exercise is not intrinsically pathological (Meyer & Taranis, 2011).

A variety of labels have been assigned to exercise behaviour that can be described as injurious on the basis of its quality (De Coverley Veale, 1987; Downs & Hausenblas, 2014; Hall, Kerr, Kozub & Finnie, 2007a; Hausenblas & Downs, 2002a). These terms have included exercise dependence, obligatory exercise, compulsive exercise, and exercise addiction, among several others (Downs & Hausenblas, 2014; Gapin, Etnier & Tucker, 2009; Hausenblas & Downs, 2002a; 2002b; Landolfi, 2012).

Although the above terms may each have a distinct meaning and slightly different connotation (Meyer & Taranis, 2011; Johnston, Reilly & Kremer, 2011), some key similarities in defining maladaptive exercise behaviour can be discerned. These include the elements of repetition, uncontrollability, physiological and psychological withdrawal symptoms in the absence of exercise, continuance despite contra-indications and negative consequences, and the predominance of exercise over other commitments and activities (De Coverley Veale, 1987; Gapin et al., 2009; Hausenblas & Downs, 2002a; 2002b; Rudy & Estok, 1989).

There is increasing acceptance among scholars that compulsive forms of exercise represent a type of behavioural addiction (Berczik et al., 2012; Downs & Hausenblas, 2014). Therefore, for the present purposes, the term exercise or *running addiction* will be used to refer to psychologically unhealthy exercise behaviour among distance runners. A more in-depth examination of this concept will be provided in the following chapter.

Prevalence of Exercise Addiction

The documented prevalence of exercise addiction has demonstrated wide variability. For example, researchers have reported prevalence rates among runners ranging from 3.2% to 77% (Egorov & Szabo, 2013). These discrepancies may be due partly to the concept being used in divergent ways (Berczik et al., 2012). In this regard, studies that have purported to measure exercise addiction have instead assessed exercise commitment, which are two distinct phenomena (Berczik et al., 2012; Terry, Szabo & Griffiths, 2004). The prevalence rate may also vary according to the specific measuring instrument used and the population assessed (Berczik et al., 2012; Egorov & Szabo, 2013). In any event, it has been claimed that paper-and-pencil type assessments of exercise addiction have no diagnostic value. Instead, even reliable measures should be viewed only as surface screening tools that indicate the risk for exercise addiction, rather than its actual prevalence (Berczik et al., 2012; Egorov & Szabo, 2013).

Despite divergent reports, it has been proposed that the prevalence of exercise addiction is, in fact, likely to be quite low (Allegre et al., 2006; Berczik et al., 2012; de Coverley Veale, 1987; Terry et al., 2004). Recent estimates suggest that the prevalence rate is 3% to 5% in the general population and about 10% in the exercising population (Downs & Hausenblas, 2014). These figures are derived from questionnaire-based assessments of the condition. Due to limitations of these measures, there are likely to be even fewer clinical cases (Berczik et al., 2012). Also, some athletes may demonstrate a preoccupation with exercise that does not represent a true dependence or addiction (de Coverley Veale, 1987). These individuals might train hard, diet to improve performance, feel guilty about missed sessions, and continue to exercise despite minor injuries (de Coverley Veale, 1987). Nevertheless, as Berczik et al. (2012) have rightly suggested, even if only 1% of exercisers display signs and symptoms of exercise addiction, this represents a large group of individuals requiring help. Furthermore, the prevalence of the disorder appears to be increasing (Krivoschekov & Lushnikov, 2011).

Consequences of Exercise Addiction

Exercise addiction was initially conceptualized as a 'positive addiction' (Allegre et al., 2006; Landolfi, 2012; Terry et al., 2004) and, unlike other additive disorders, is viewed as socially acceptable (Egorov & Szabo, 2013). However, these perspectives belie the potentially serious and destructive nature of the disorder. Downs and Hausenblas (2014) have argued that exercise addiction is both physically and psychologically damaging, while many other researchers (Adams, 2009; Allegre et al., 2006; Berczik et al., 2012; de Coverley Veale, 1987; Gapin et al., 2009; Hausenblas & Giacobbi, 2004; Khatri & Blumenthal, Landolfi, 2012; Terry et al., 2004) have also alluded to its harmful effects. For example, Berczik et al. (2012) have stated that "the socially praised benefits of exercise should be presented with caution and warning that exercising when losing control over the behaviour can potentially be as dangerous to a person's health as the misuse of any other behaviour or substance" (p. 412). These authors have also referred to "the negative consequences of the self-destructive behaviour in exercise addiction" (Berczik et al., 2012, p. 408). Similarly, Terry et al. (2004) have argued that exercise is generally a rewarding behaviour, but an obsessive approach could detrimentally alter one's lifestyle, with adverse physical, medical, financial, and social consequences.

Individuals who are addicted to exercise are likely to experience severe withdrawal symptoms in the absence of exercise (Landolfi, 2012). These symptoms include depression, anxiety, emotional strain, somatic complaints, and insomnia (Morris, Steinberg, Sykes & Salmon, 1990). Behavioural addictions are also related to the neglect of work and family responsibilities (Berczik et al., 2012; Gapin et al., 2009), while the prioritization of exercise over important relationships can cause interpersonal difficulties (Iannos & Tiggemann, 1997; Landolfi, 2012). Additionally, an all-consuming focus on exercise could lead to the exclusion of important values, such as friendship. This could upset the balance in a person's life – with further negative implications for well-being (Bloodworth & McNamee, 2007). Moreover, by virtue of their compulsive and inflexible training patterns and intense preoccupation with exercise, addicted exercisers may experience greater physical and psychological stress (Adams & Kirkby, 2001; Berczik et al., 2012). This may, in turn, render them more susceptible to injuries and upper respiratory infections. Chronic stressor exposure as a result of exercise addiction may also increase athletes' risk of developing the overtraining syndrome (Adams & Kirkby, 2001).

Rationale behind the Present Study

As already alluded to, distance running is generally associated with enhanced physical health and psychological well-being. However, injuries and infectious illness or an obsession with exercise could offset these benefits and have detrimental consequences. This underscores the value of conducting research aimed at increasing understanding of the risk factors associated with these disorders. Studies of this kind may help to suggest effective strategies for keeping runners physically and psychologically healthy, enabling them to maximize the rewards afforded by regular exercise.

Compared to the fairly large volume of research examining the psychological benefits of physical activity, it seems that little is known about the phenomenon of psychologically harmful exercise. Berczik et al. (2012) have stated that there is presently a narrow understanding of the concept of exercise addiction, and many aspects of this condition remain unexplored. For example, factors involved in the development of this disorder are largely unknown (Hall, Hill, Appleton & Kozub, 2009). Additionally, a perusal of the literature indicates that there is currently limited knowledge of the impact of compulsive exercise on overuse injury and infectious illness risk in distance runners.

Moreover, despite fairly extensive investigation, the influence of *training load* on injuries and URTIs in runners is still not clear. Training load refers to quantitative dimensions of exercise, such as training volume and intensity, frequency of competitions, and the stress-recovery relationship (Kellmann & Altfeld, 2014a). Given that runners' training regimens may have physical health consequences, identifying the antecedents of typical exercise patterns may also be important. However, it appears that not much is known about this topic.

A brief overview of previous research pertaining to the psychological risk factors for exercise addiction, and the effects of qualitative and quantitative dimensions of exercise behaviour on injuries and infectious illness in distance runners is presented below. A more comprehensive review of the empirical literature will be provided in Chapter 3.

Psychological Antecedents of Exercise Behaviour

Personality Predictors

There is growing evidence that personality dispositions may be important predictors of exercise addiction and related constructs (Basson, 2001; Gulker, Laskis & Kuba, 2001; Hausenblas & Giacobbi, 2004; Lichtenstein, Christiansen, Elklit, Bilenberg & Stoving, 2014; Miller & Mesagno, 2014). One of these personality variables is the trait of *perfectionism*. Perfectionism can be defined as a multidimensional construct that is characterized by very high personal standards and overly critical self-evaluations (Frost, Marten, Lahart & Rosenblate, 1990).

A small body of research has indicated that perfectionism may be an important risk factor for exercise addiction in populations of college students and general exercisers (Downs, Hausenblas & Nigg, 2004; Gulker et al., 2001; Hagan & Hausenblas, 2003; Hill, Robson & Stamp, 2015; Miller & Mesagno, 2014; Taranis & Meyer, 2010). A relationship between perfectionism and measures of maladaptive exercise behaviour has also been documented in British distance runners (Hall et al., 2007a; Hall, Hill, Appleton & Kozub, 2007b; Hall et al., 2009). However, further research is needed to confirm this association and to determine whether these results are generalizable to a South African running population.

Although it has been suggested that perfectionism may also influence the training levels of endurance athletes (Williams & Andersen, 2007), there is no direct evidence to support this hypothesis. However, various studies have found a relationship between dimensions of perfectionism and susceptibility to burnout in athletes (Lemyre, Roberts, Stray-Gundersen, Treasure & Hall, 2003; Appleton, Hall & Hill, 2009). Burnout has been defined as syndrome that includes emotional and physical exhaustion – probably related to the demands of intense training and competition (Raedeke, 2014). This suggests a potential link between perfectionism and training load. However, research is needed to investigate this possibility.

Another personality disposition that may affect qualitative and quantitative dimensions of exercise behaviour is the *Type A behaviour pattern*. This construct comprises a cluster of related traits that include aggressiveness, competitiveness, hyperactivity, ambitiousness, impatience, time urgency, and anger/hostility (Blumenthal, Herman, O'Toole, Haney, Williams & Barefoot, 1985; Fields et al., 1990; Smith & Anderson, 1986; Steinberg, 1985; Thoresen & Powell, 1992). Type A individuals also tend to have very high personal standards (Ward & Eisler, 1987), to display excessive achievement striving, and to have a hard-driving approach to tasks (Burnman, Pennebaker & Glass, 1975).

Traditionally, the Type A trait has been studied in relation to cardiovascular disease risk (Blumenthal et al., 1985; Lidor, 2014). A few researchers (Diekhoff, 1984; Ekenman et al., 2001; Fields et al., 1990) have also discovered a link between Type A behaviour and increased running injury incidence. It is conceivable that dysfunctional training patterns, such as running excessive weekly distances and exercising despite pain or discomfort, may account for this relationship (Ekenman et al., 2001; Fields et al., 1990). This suggests that Type A behaviour may predict an increased risk for exercise addiction and/or heavier training loads in distance runners. However, in what seems to be the only study to have tested this assertion, Fields et al. (1990) found no relationship between the Type A construct and self-reported weekly training distance in runners (Fields et al., 1990). Still, this study did not consider the impact of Type A behaviour on other training variables, such as the frequency or intensity of workouts. Further, to the best of the author's knowledge, the potential for Type A behaviour to predict exercise addiction or similar constructs has not yet been empirically investigated. Therefore, this may represent a fruitful area of future research.

Various models and theories pertaining to the perfectionism and Type A constructs imply that maladaptive cognitions and/or stress-related factors may mediate the relationship between these personality traits and potentially harmful dimensions of exercise behaviour (Ellis, 2002; Martin, Kuiper & Westra, 1989). These personality dispositions, as well as theoretical perspectives that are relevant to understanding their association with exercise/running addiction and training load, will be examined more thoroughly in the next chapter.

Achievement Goal Orientations

Aside from personality characteristics, it is conceivable that motivational factors, such as *achievement goal orientations*, may influence dimensions of distance running participation. Achievement goal orientations are cognitive schemas that guide achievement behaviour in sport and educational contexts (Roberts, Treasure & Conroy, 2007). Persons may be inclined to have a task and/or ego goal orientation, which refers to the disposition to act in a task- and/or ego-involved manner, respectively (Roberts, Treasure & Balague, 1998; Roberts et al., 2007). The goal of task-involved individuals is mastery, improvement, or learning, whereas ego-involved persons are focused mainly on outperforming others, preferably with less effort (Roberts et al., 2007).

Research examining the correlates and consequences of achievement goal orientations in sport and exercise domains suggests that task goals are related to adaptive cognitions, emotions, and behaviours, such as interest, enjoyment, achievement satisfaction, effort, persistence, and commitment (Biddle, Wang, Kavussanu & Spray, 2003; Conroy & Hyde, 2014; Roberts et al., 1998). Conversely, the research data imply that ego goals usually predict less desirable outcomes, such as anxiety, worry, competitiveness, and public self-consciousness (Conroy & Hyde, 2014).

Researchers have also found a relationship between achievement goal orientations and the risk of burnout in elite athletes (Isoard-Gautheur, Guillet-Descas & Duda, 2013; Lemyre et al., 2003). As burnout is affected by training patterns (Raedeke, 2014), it is reasonable to assume that goal orientations may influence the quality and/or quantity of exercise behaviour in runners. There is, however, scant empirical support for this assertion. The exception was a study conducted by Hall et al. (2007a) among British distance runners. The results of this investigation indicated that achievement goals were strongly related to obligatory exercise behaviour in these athletes. This discovery has provided preliminary support for the role of goal orientations in exercise addiction in runners. However, this finding would need to be confirmed in other studies involving distance runners before any definitive conclusions can be drawn in this regard. Also, it is uncertain whether the results of this research are applicable to South African distance runners. A more complete exposition of the concept of achievement goal orientations will be presented in Chapter 2.

Effects of Exercise Behaviour on Running Injuries

Exercise/Running Addiction Studies

Many researchers believe that exercise addiction is a risk factor for athletic injuries (Adams & Kirkby, 1998; Adams & Kirkby, 2001; Berczik et al., 2012; de Coverley Veale, 1987; Downs & Hausenblas, 2014; Gapin et al., 2009; Hays, 2004; Iannos & Tiggemann, 1997; Landolfi, 2012; Lichtenstein et al., 2014). A small body of research involving populations of general exercisers (Lichtenstein et al., 2014) and distance runners (Diekhoff, 1984; Ekenman et al., Layman & Morris, 1991; Rudy & Estok, 1989) supports this view. However, studies involving runners seem to have mainly utilized unidimensional instruments to assess problem exercise behaviour. Since exercise addiction is increasingly recognized as a multifaceted construct, unidimensional tools may fail to provide an adequate assessment of the disorder (Downs & Hausenblas, 2014; Hill et al., 2015). This indicates that further research utilizing multidimensional measures of exercise addiction is needed to confirm this relationship. Furthermore, all of the above-mentioned studies were conducted overseas. Therefore, additional investigation could help to establish whether exercise addiction predicts overuse injury risk in South African distance runners.

Training Load Studies

In general, the results of research examining the relationship between training load and running injuries has yielded inconsistent findings (Nielsen et al., 2012). For example, several authors have reported that high training volumes may be a risk factor for running injuries (Ryan et al., 2006; Schueller-Weidekamm, Schueller, Uffmann & Bader, 2006; van Gent et al., 2007). However, this relationship has not been confirmed in other studies (Ellapen et al., 2013; Fields et al., 1990; Rudy & Estok, 1989). Research investigating the role of additional training variables, such as the number and intensity of weekly workouts, in injury incidence has also demonstrated conflicting results (Nielsen et al., 2012). However, there is some evidence that running a higher number of races per annum may increase injury risk (van Middelkoop et al., 2008; Layman & Morris, 1991). Following a systematic review of published reports addressing training errors and running injury risk, Nielsen et al. (2012) decided that, on the basis of heterogeneous research findings, it could not conclusively be determined which training characteristics were related to running injuries. Therefore, further research may help to clarify the relationship between quantitative dimensions of endurance training and running injury incidence.

Effects of Exercise Behaviour on URTIs

Exercise/Running Addiction Studies

The relationship between pathological forms of exercise behaviour and susceptibility to upper respiratory tract infections in sport and exercise domains seems to have received scant attention from investigators to date. In fact, a search of the available literature failed to unearth any studies exploring the role of running addiction or related constructs in athletes' risk of developing an infectious illness. This underlines the need for further empirical work in this field.

Training Load Studies

In contrast to the status of exercise addiction research, a fairly large number of researchers in South Africa and abroad have explored the role of training factors in URTI risk in distance runners. However, contradictory findings have been reported. For example, several investigators have observed a positive relationship between chronic and/or acute heavy exercise and URTI incidence (Heath et al., 1991; Linde, 1987; Nieman, Johanssen, Lee & Arabatzis, 1990b; Peters & Bateman, 1983; Peters, Goetzsche, Grobbelaar & Noakes, 1993; Robson-Ansley et al., 2012). Conversely, some researchers have found no significant association between measures of training load and infectious symptoms (Ekblom, Ekblom & Malm, 2006; Fricker et al., 2005; Struwig, Papaikonomou & Kruger, 2006). Moreover, other studies have reported an inverse relationship between these variables (Martensson, Nordebo & Malm, 2014; Nieman, 1997; Peters, Goetzsche, Joseph & Noakes, 1996). In a systematic review of the literature, Moreira, Delgado, Moreira and Haahtela (2009) concluded that the role of endurance exercise in URTI risk was generally inconclusive. However, these authors remarked that there was some evidence that the strenuous effort of running a marathon may increase susceptibility to infection. Additional research may help to provide some clarity on these issues.

Objectives of the Present Study

It can be proposed that increased knowledge of the risk factors associated with overuse injuries, infectious illness, and exercise addiction in distance runners may enhance insight into these disorders and help to suggest appropriate prevention and/or treatment strategies designed to keep runners healthy. Similarly, a greater understanding of the psychological determinants of quantitative dimensions of exercise behaviour may have indirect implications for runners' physical health status.

Against this background, the primary aim of the present study was to investigate the personality and motivational antecedents of running addiction and training load, and the impact of these variables, in turn, on overuse injuries and URTIs in South African athletic club members. Thus, the main focus of this research was to address the following research questions:

- Do perfectionism, Type A behaviour pattern, and achievement goal orientations affect running addiction risk and habitual training load?

- Do running addiction and training load influence susceptibility to running injuries and upper respiratory tract infections?

Secondary goals of this study were to assess the effects of running addiction on training load and to examine specific bivariate relationships among perfectionism, Type A behaviour, and achievement goal orientations.

The intention was to examine these relationships using the sophisticated multivariate statistical analysis technique of *structural equation modelling* (SEM). In brief, SEM provides a flexible means of investigating complex interrelationships among multiple variables

(Waters et al., 2007) and allows researchers to test causal theories using nonexperimental data (Martin, 1987). This statistical procedure will be described in more detail in Chapter 4.

Significance of the Present Study

The current study may have both theoretical and practical significance. For example, by exploring the effects of perfectionism, Type A behaviour pattern, and achievement goal orientations on running addiction, this investigation may help to elucidate the role of personality and motivational factors in pathological exercise behaviour. As noted previously, there is presently limited knowledge of the factors underlying exercise addiction. This study may assist in corroborating prior research attesting to the influence of perfectionism on exercise addiction. It may also serve to identify additional, unexplored precursors of pathological forms of exercise behaviour, such as the Type A behaviour pattern. It is possible that the results yielded by this research may have wider implications for understanding behavioural addictions in general.

Investigation of the effects of exercise addiction on running injuries could help to confirm previous research findings and shed more light on the role of pathological exercise behaviour in injury incidence. Furthermore, examination of the influence of running addiction on URTIs could serve to establish whether this disorder has physical health implications beyond athletic injuries. On a broad level, study of these associations could aid in illuminating the relationship between psychological and physical health in endurance athletes.

Additionally, this investigation could assist in clarifying the relationship between quantitative dimensions of distance running and overuse injury and URTI risk. As mentioned earlier, previous research in this field has generally yielded inconsistent findings. Simultaneous examination of specific psychological influences on training patterns in runners could arguably provide deeper insight into this issue.

The utilization of the powerful multivariate statistical analysis technique of SEM to investigate the network of associations among personality, motivation, running addiction, training load, and running injury and URTI risk could allow more definitive conclusions to be drawn from the data analysis. This could arguably facilitate increased understanding of the research problem.

The findings of this study may, in turn, have practical implications for the psychological and physical health of distance runners. For instance, identifying the determinants of exercise addiction could help practitioners to recognize at-risk individuals, assisting with early diagnosis and prevention strategies (Krivoschekov & Lushnikov, 2011). Similarly, knowledge of training-related influences on running injury and URTI risk could aid in determining suitable injury prevention/or treatment strategies, as required.

Finally, there are many published reports describing the impact of training volume on common physical health disorders in South African distance runners. However, few, if any studies seem to have considered the health implications of the psychological quality of exercise behaviour. Further, it appears that little is known about the psychological factors that may predispose some runners to exercise in potentially harmful ways. This lack of research may be significant because, due to social, cultural, economic, and other differences, it is uncertain whether the findings of studies conducted in other countries are generalizable to South African runners. By addressing this question, this investigation may not only facilitate understanding of these issues but also perhaps pave the way for further research in this field. This may ultimately have significant practical repercussions for the physical health and psychological well-being of South African distance runners.

Structure of the Thesis

In order to orientate the reader, a brief outline of the structure of the thesis is provided. In the chapter that follows, the theoretical framework of the current study is presented and examined. The main purpose of this section is to justify, on theoretical grounds, the inclusion of specific study variables, to define key constructs, and to discuss theories and models that are relevant to the research topic. Chapter 3 investigates and reviews previous research pertaining to important concepts and relationships, identifying areas of agreement, inconsistency, and/or uncertainty in this body of work. In Chapter 4, the research hypotheses and design and methodological aspects of the study are described, while the study results are presented and delineated in Chapter 5. In the subsequent section, the research findings are discussed with reference to the research hypotheses and in light of theory and research. The concluding chapter of this thesis addresses the potential contribution of the present research to current knowledge and practice and discusses the study’s limitations. Finally, various recommendations are provided for future research.

CHAPTER 2

PSYCHOLOGICAL FACTORS, EXERCISE BEHAVIOUR, INJURIES, AND URTIS: THEORETICAL PERSPECTIVES

Introduction

The main objective of this chapter is to provide a theoretical framework for the present study. This will comprise a process of identifying, defining, explaining, and critically examining key constructs, models, and theories, as appropriate. There are three primary aims of this section: (1) to explore various approaches to the conceptualization and aetiology of exercise addiction and related constructs, (2) to investigate the potential psychological basis of qualitative and quantitative dimensions of exercise behaviour, and (3) to present and assess theoretical perspectives relevant to understanding the impact of exercise addiction and training load on running injuries and upper respiratory tract infections (URTIs).

Disciplinary Context of the Current Study

At the outset, it is useful to define the disciplinary context of the present study in order to provide a broad perspective of the research problem. This study can be described as cross-disciplinary. Investigation of the psychological and physical health risks associated with distance running falls within the realms of scientific disciplines like sports medicine, and sport and exercise science. The current research also addresses issues that are pertinent to two subdisciplines of psychology, specifically sport and exercise psychology, and health psychology. A brief description of these overlapping branches of psychology and their primary areas of interest is provided below.

Sport and Exercise Psychology

Sport and exercise psychology is a multifaceted discipline that involves “psychological theory and research directed to the understanding of human behaviour in and through sport” (Morris & Thomas, 1995, p. 216). This field of study is concerned with issues such as psychosocial influences on athlete health, sport performance, and sport and exercise behaviour, as well as the effects of sport and exercise on psychological functioning.

Sport psychology and exercise psychology may also be viewed as disciplines in their own right (Grove, 1995). Slight differences can be discerned in the primary areas of focus of each field. For example, sport psychologists are interested in studying topics such as the effects of emotions, cognitions, and behaviours of sport participants on factors like sport injury risk (Wiese-Bjornstal, 2010). Meanwhile, exercise psychologists are mainly concerned with understanding the psychological antecedents, correlates, and consequences of exercise behaviour (Grove, 1995). Exercise behaviour refers to an array of physical activities related to strength and endurance, fitness, body composition, and flexibility. The antecedents, correlates, and consequences of exercise behaviour may be emotional, cognitive, or behavioural in nature. Examples of predictor variables include personality and self-perceptions, while correlates and outcomes of exercise behaviour comprise factors like perceived exertion, and exercise addiction, respectively (Grove, 1995).

Despite these distinctions, sport and exercise have a close relationship, as definitions provided by the *Collins English Dictionary* (2006) suggest. For example, sport is defined as “an activity for exercise, pleasure, or competition (p. 801), while exercise is defined as “physical exertion, especially for training or keeping fit” (p. 274). Therefore, sport may be undertaken for physical fitness purposes, while training for sport may involve physical exertion.

Health Psychology

In its broadest sense, the discipline of health psychology is a scientific field that focuses on the application of psychological theory and practice to health promotion and illness development, maintenance, prevention, and treatment (Rohleder, 2012). This scientific discipline draws on the biopsychosocial model of health and disease (Gallo & Luecken, 2008; Rohleder, 2012), which is discussed later in this chapter. Health psychology is concerned with topics such as pain, stress and coping, the patient-doctor interaction, and health-related behaviours like physical activity and substance use (Rohleder, 2012). For example, research in this field may include the effects of stress and negative emotions on the aetiology and progression of cancer and cardiovascular disease (Gallo & Luecken, 2008) or the impact of lifestyle factors, such as exercise, on health promotion and disease prevention.

Exercise Addiction

Defining Addiction

Most people arguably have an informal understanding of the meaning of the word, addiction. However, from a scientific perspective, addiction is a difficult concept to define, and it is generally easier to recognize the whole than the parts (Griffiths, 1996). Contemporary theorists like Albanese and Shaffer (2012) have argued that addiction is a complex construct and should be conceptualized as a syndrome.

Consistent with this view, it has been maintained that addiction is not limited or equivalent to physiological dependence (Albanese & Shaffer, 2012; Sussman, Lisha & Griffiths, 2011). Physiological/biological dependence is manifested in tolerance and withdrawal effects and is a consequence of neuroadaptation to a sustained behaviour, such as drug usage (Albanese & Shaffer, 2012; Black, Kuzma & Shaw, 2012). Tolerance has been defined as "the observation than an increased dose is needed to experience the same subjective effects experienced with a lower dose before" and withdrawal as "a stereotypical pattern of discomfort on stopping use that resumed use can alleviate" (Albanese and Shaffer, 2012, p. 4). Physiological dependence is not a necessary condition for the presence of addiction, while dependence or neuroadaptation can also occur in the absence of an addictive disorder (Albanese & Shaffer, 2012).

Albanese and Shaffer (2012) have further contended that addictions all belong in the same general class and have similar symptoms, causes, and effects. For example, it has been proposed that "addiction is an expression of multidimensional influences that affect vulnerable people. Not all the symptoms and signs of addiction are present at all times. Behavioural and chemical expressions of addiction have similar aetiology and consequences" (Albanese & Shaffer, 2012, p. 12).

Although the term, addiction, generally brings to mind substance use disorders pertaining to the ingestion of alcohol or illicit drugs, the object of an addiction may be behavioural in nature. Scholars in the field have made a distinction between substance and process addictions (Griffiths, 1996). Substance addiction involves the misuse of ingested products, such as alcohol, nicotine, or drugs. Process or behavioural addiction refers to potentially pathological behaviours “whose overt symptoms are behaviourally expressed, and are viewed – at least initially – as pleasurable (for example, gambling, sex, shopping and Internet use), and have attained an irresistible quality, such as the substance addictions” (Black, 2013, p. 249).

In terms of the specific object of addiction, any substance or activity that consistently and reliably produces a desirable change in subjective experience could become addictive (Albanese & Shaffer, 2012). Stated differently, addiction is not a property of the object or behaviour itself but is related to the positive emotional experience that it elicits. In support of this idea, it has been shown that substance and behavioural addictions have many commonalities. For example, they share core clinical features, such as compulsivity and uncontrollability, as well as the symptoms of tolerance, withdrawal, and pervasive impairment (Black et al., 2012). The following definition of addiction offered by Krivoschekov and Lushnikov (2011) serves to capture the generic nature of the disorder:

> “Addictive behaviour is an attempt to escape real life by means of artificially changing one’s own physical state by taking drugs or performing certain activities. Depending on the means of escape, pharmacological or chemical and nonchemical or behavioural addictions may be distinguished” (p. 509).

In delineating the core features of behavioural addiction, Sussman et al. (2011) have claimed that addiction essentially involves a preoccupation with a behaviour that initially produced desirable effects. The behaviour is performed repeatedly although with several pattern variations, such as bingeing or sustained preoccupation. An addiction is also associated with a loss of control over the behaviour and with adverse physical, psychological, social, behavioural, and financial consequences (Sussman et al., 2011). For example, an addictive disorder can impair social and occupational functioning, increase the risk of physical injury and illness, lead to legal problems, and result in decreased interest and enjoyment in hobbies and other activities. Even though clear symptoms of physical dependence may be absent in an addiction, termination of the behaviour may lead to adverse psychological symptoms, such as depression, intense anxiety, and irritability (Sussman et al., 2011).

Defining Exercise Addiction

Exercise addiction can be considered a unique form of addiction as, unlike other addictions, which are more passive in nature, this form of addictive behaviour involves major physical effort (Egorov & Szabo, 2013). Broadly-speaking, exercise addiction may be understood as exercise behaviour that combines the elements of dependence and compulsiveness (Berczik et al., 2012). This implies that exercise addiction may be viewed as a multidimensional construct that has behavioural, physiological, and psychological components. Other terms used for exercise addiction include exercise dependence, obligatory exercise, and compulsive exercise (Downs & Hausenblas, 2014).

Although exercise addiction can be described in general terms, a more precise, universally accepted definition of the concept appears to be elusive. Several conceptualizations highlighting one or more facets of the disorder have been developed since exercise addiction was first described in the literature more than four decades ago (Allegre et al., 2006). These definitions have focused on psychological (e.g., pathological commitment), behavioural (e.g., exercise frequency or duration) physiological (e.g., tolerance) and/or psychosocial (e.g., impairment of social functioning) facets of the construct (Hausenblas & Downs, 2002a).

Adams and Kirkby (1998) defined exercise addiction as “a condition in which moderate to intense physical activity becomes compulsive behaviour” (p. 265), thus emphasising psychological aspects of the construct. Some researchers have highlighted the harmful consequences of exercise addiction. For instance, Adams (2009) maintained that “exercise dependence represents a condition in which an individual exercises excessively, often to the detriment of his or her physical and psychological health and wellbeing” (p. 231). Hausenblas and Cook (2014) have offered a more comprehensive definition of the construct, describing exercise addiction as “a craving for leisure-time physical activity, resulting in uncontrollably excessive exercise behaviour that manifests itself in physiological (e.g., tolerance/withdrawal) or psychological (e.g., withdrawal) symptoms” (p. 230).

Currently, the condition of exercise addiction is not listed as a psychological disorder in any officially recognized medical or psychological diagnostic manual. However, several scholars have proposed various criteria that could assist in detecting potentially harmful exercise behaviour. De Coverley Veale (1987) advocated a set of standards for diagnosing exercise addiction based on established diagnostic criteria for substance dependence. This author proposed that exercise addiction could be identified on the basis of the following signs and symptoms (de Coverley Veale, 1987, p. 736):

- Narrowing of repertoire leading to a stereotyped pattern of exercise with a regular schedule once or more daily;
- Salience with the individual giving increasing priority over other activities to maintaining the pattern of exercise;
- Increased tolerance to the amount of exercise performed over the years;
- Withdrawal symptoms related to a disorder of mood following cessation of the exercise schedule;
- Relief or avoidance of withdrawal symptoms by further exercise;
- Subjective awareness of a compulsion to exercise;
- Rapid reinstatement of the previous pattern of exercise and withdrawal symptoms after a period of abstinence.

De Coverley Veale (1987) added two further features that could suggest the presence of an exercise disorder. First, the normal exercise pattern is continued in spite of medical, interpersonal, or career problems that are directly related to the behaviour. Second, the exercise behaviour is associated with a concomitant desire for weight loss in order to improve performance.

Subsequent modifications to these criteria highlighted the following signs and symptoms of exercise addiction: (1) intense preoccupation with exercise that is not adequately explained by another mental disorder, (2) fixed exercise routines, (3) severe withdrawal symptoms in the absence of exercise, and (4) significant associated distress and impairment in functioning (Landolfi, 2012).

In expanding on de Coverley Veale's definition, (Hausenblas & Downs, 2002a) recommended that exercise addiction be operationalized as a "multidimensional, maladaptive pattern of exercise that leads to clinically significant impairment or distress" (p. 113). These authors proposed seven diagnostic criteria for exercise addiction that are consistent with this definition. These are listed in Table 2.1. The occurrence of three or more of these symptoms in the same 12-month period may indicate an increased risk for an exercise-related disorder.

Table 2.1

Exercise Addiction Diagnostic Criteria (Downs & Hausenblas, 2014, p. 267)

Criteria	**Description**	**Example**
Tolerance	Need for increased exercise levels to achieve the desired effect, or diminished effects experienced from the same exercise level.	Running 5 miles (8 kilometres) no longer results in improved mood.
Withdrawal	Negative symptoms are evidenced with cessation of exercise, or exercise is used to relieve or forestall the onset of these symptoms.	Anxiety, depression, or fatigue experienced when unable to exercise.
Intention	Exercise is undertaken with greater intensity, frequency, or duration than was intended.	Intended to run for 5 miles (8 kilometres) but ran for 7 miles (11 kilometres) instead.
Lack of Control	Exercise is maintained despite a persistent desire to cut down or control it.	Ran during lunch break despite trying not to exercise during work hours.
Time	Considerable time is spent in activities essential to exercise maintenance.	Vacations are exercise related, such as skiing and hiking trips.
Reduction in Other Activities	Social, occupational, or recreational pursuits are reduced or dropped because of exercise.	Running rather than going out with friends for dinner.
Continuance	Exercise is maintained despite the awareness of a persistent physical or psychological problem.	Running despite shin splints.

In view of the commonalities among behavioural and substance addictions (Black, 2013; Black et al., 2012; Griffiths, 1996; Downs & Hausenblas, 2014), it may, however, be most appropriate to conceptualize problem exercise behaviour within a general addiction framework. In support of this, Griffiths (1996, 1997) successfully demonstrated that the six components of addiction proposed by Brown (as cited in Griffiths, 1997) could also be applied to behavioural addictions. Consequently, Terry et al. (2004, pp. 490-491) proposed the following set of criteria as a basis for the assessment of exercise addiction:

- **Salience –** This occurs when the particular activity becomes the most important activity in the person's life and dominates their thinking (preoccupations and cognitive distortions), feelings (cravings), and behaviour (deterioration of socialized behaviour). For instance, even if the person is not actually engaged in the behaviour they will be thinking about the next time they will be.

- **Mood modification –** This refers to the subjective experiences that people report as a consequence of engaging in the particular activity and can be seen as a coping strategy (i.e., they experience an arousing 'buzz' or a 'high', or paradoxically tranquilising feel of 'escape' or 'numbing').

- **Tolerance –** This is the process whereby increasing amounts of the particular activity are required to achieve the former positive effects. For instance, a gambler may have to gradually increase the size of the bet to experience a euphoric effect that was initially obtained by a much smaller bet.

- **Withdrawal symptoms –** These are the unpleasant feeling states and/or physical effects which occur when the particular activity is discontinued or suddenly reduced, e.g., the shakes, moodiness, irritability etc.

- **Conflict –** This refers to the conflicts between the addict and those around them (interpersonal conflict), conflicts with other activities (job, social life, hobbies, and interests) or from within the individual themselves (intrapsychic conflict) which are concerned with the particular activity.

- **Relapse –** This is the tendency for repeated reversions to earlier patterns of the particular activity to recur and for even the most extreme patterns, typical of the height of the addiction, to be quickly restored after many years of abstinence or control.

A specific strength of the above approach is that it underscores the status of exercise addiction as a bona fide addictive disorder while acknowledges the common biopsychosocial foundation of addiction. It has been argued, however, that not all of the general components of addiction can be applied to exercise addiction (Cockerill & Riddington, 1996). Unlike other potentially addictive behaviours, such as gambling, shopping, or alcohol use, exercise is associated with considerable physical and psychological effort and stubborn willpower. Therefore, the relapse component of addiction may not be relevant to exercise due to the inherent difficulties of resuming excessive exercise behaviour after a period of inactivity (Cockerill & Riddington, 1996). It has also been cautioned that by conceptualizing problematic exercise within a general addiction framework, care should be taken to avoid stigmatizing the phenomenon or adopting a solely medical approach (Berczik et al., 2012).

Exercise Addiction: Conceptual and Diagnostic Issues

It has been noted that the expression, exercise addiction, has tended to be misused among runners and researchers alike. Frequently, behaviour that represents a strong commitment to exercise has been incorrectly labelled an addiction (Landolfi, 2012; Terry et al., 2004). This trend emerged partly because it was originally proposed that excessive exercise was a 'positive addiction' due to its psychological and physiological benefits (Allegre et al., 2006; Landolfi, 2012; Terry et al., 2004). Consequently, the term, addiction, has often been used to refer to what may be, in fact, a strong sense of commitment to exercise (Landolfi, 2012). In any event, the term, positive addiction, would seem to be a contradiction in terms as addiction is, by definition, a negative phenomenon.

It has been proposed that addiction can be distinguished from commitment on the basis of the severity of withdrawal symptoms, the importance of exercise in an individual's life, and motives for exercise. Sachs (as cited in Terry et al., 2004) posited that exercise addiction is associated with severe withdrawal symptoms, is a central part of a person's life, and is intrinsically motivated. In contrast, committed exercisers experience less intense deprivation symptoms, view exercise as important but not pivotal to their existence, and are motivated by extrinsic rewards, such as performance concerns or weight loss. A further proposed distinction between the committed and addicted exerciser is that the former enjoys and is energized by exercise, whereas the latter has begun to view exercise as a chore (Cockerill & Riddington, 1996). Ultimately, one can distinguish committed versus addicted exercisers primarily on the basis that healthy, committed exercisers organize exercise around their lives, whereas unhealthy, addicted exercisers organize their lives around exercise (Downs & Hausenblas, 2014).

Scholars and researchers have also emphasized the importance of making a distinction between primary and secondary exercise addiction (Berczik et al., 2012; de Coverley Veale, 1987; Downs & Hausenblas, 2014). Essentially, primary and secondary exercise addiction can be differentiated on the basis of the underlying objective. Secondary exercise addiction occurs in association with an eating disorder, and weight loss or other bodily concerns drive the pathological behaviour. Conversely, primary exercise addiction occurs in the absence of an eating disorder and is motivated by factors directly related to the exercise experience, such as mood regulation (Berczik et al., 2012; Downs & Hausenblas, 2014). Therefore, primary and secondary exercise addiction each has a different aetiology (Berczik et al., 2012). A diagnosis of primary exercise addiction should only be made once an eating disorder, such as anorexia or bulimia nervosa, has been excluded (de Coverley Veale, 1987). In the case of a diagnosis of secondary exercise addiction, the main focus of treatment is the underlying eating disorder (Downs & Hausenblas, 2014). The current study is concerned with exercise addiction as a primary disorder.

In conclusion, it appears that, in common with other addictive disorders, exercise addiction is a complex and multifaceted condition with diverse features, symptoms, and outcomes. Drawing on the different conceptualizations of the construct, exercise addiction may be viewed as a compulsive and inflexible pattern of exercise that governs a person's life to the detriment of physical, psychological, and social functioning. The 'compulsive' element of this description refers to the repetitive and mainly uncontrollable nature of the behaviour, which is related to the desire to experience pleasure and/or to relieve negative affect. The 'inflexible' component describes the tendency for addicted exercisers to continue to maintain their rigid schedules despite the threat of harmful consequences. The current perspective also encapsulates the dimension of salience in the sense that exercise governs all aspects of a person's life, including cognitions, emotions, and behaviours.

Additionally, this conceptualization reflects the view that exercise addiction typically has adverse biological, psychological, and/or social consequences. Biological and psychological harm includes adverse symptoms associated with tolerance and withdrawal effects. Exercise addiction may also impair social and occupational functioning and increase the risk of stress, depression, injuries, and illness. Finally, this definition implies that exercise addiction is likely to predict heavier training loads among endurance athletes and could also increase the risk of overtraining.

Theories and Models of Exercise Addiction

A number of models and theories have been formulated in order to explain the development and maintenance of primary exercise addiction and related constructs. Models and theories of exercise addiction have included both physiological and psychological explanations.

Physiological Perspectives on Exercise Addiction

Berczik et al. (2012) have described four physiological explanations for exercise addiction. These include the endorphin hypothesis, the catecholamine hypothesis, the sympathetic arousal hypothesis, and the thermogenic regulation hypothesis. Each of these theoretical perspectives will be briefly presented and evaluated.

What may be the oldest explanation is the endorphin or 'runner's high' hypothesis, which centres on the role of beta-endorphin activity in the brain. According to this theory, an activity like distance running elicits increased secretions of beta-endorphin (endogenous morphine), which results in feelings of intense euphoria. In common with morphine, it has been hypothesized that endorphins may lead to dependence. While intuitively appealing, Berczik et al. (2012) have stated that a serious drawback to this theory is that the elevated beta-endorphin levels induced by exercise have only been observed peripherally – in plasma levels – and not in the brain itself. Also, due to their chemical structure, beta-endorphins are unable to cross the blood–brain barrier.

The catecholamine hypothesis is based on the assumption that intense exercise increases levels of catecholamines (adrenalin and noradrenaline) in the brain. Among other functions, central catecholamine activity influences mood and plays a key role in the reward system. These effects may serve as positive reinforcement for continued exercise. According to Berczik et al. (2012), this theory suffers from a similar limitation to that of the endorphin hypothesis. Changes in peripheral catecholamine levels have been observed in response to exercise but not in the brain itself, which is inaccessible to direct study.

Another explanation for exercise addiction is the sympathetic arousal hypothesis which specifies that exercise addiction is a function of the need to increase physiological arousal levels. It is posited that regular aerobic exercise results in a training effect, which is marked by a lower resting heart rate and reduced sympathetic activity. These changes lead to decreased arousal levels at rest, which may be experienced as a state of lethargy. Further exercise serves as a mechanism to increase arousal levels in order to attain optimal functioning. However, since these adaptation effects are universal, this theory implies that most exercisers may be at risk for addiction, which is not supported by research (Egorov & Szabo, 2013).

Finally, the thermogenic regulation hypothesis suggests that exercise-induced increases in body temperature underlie exercise addiction. It has been stated that exercise elevates body temperature, which is associated with reduced anxiety and enhanced relaxation. Further exercise is then undertaken in order to reproduce these effects, and the amount of exercise is increased during stressful periods. Due to adaptation effects, greater amounts of exercise are needed over time to achieve the same outcomes.

Although advanced as theories of exercise addiction, it seems that none of the above theories can fully explain the all-consuming nature of the disorder. It could be argued that these perspectives do not adequately account for the extent of addicted exercisers' preoccupation with exercise to the point where it becomes a destructive force in their lives. These hypotheses may serve as more valid explanations for the adoption of heavy exercise loads and thus could perhaps contribute towards an increased understanding of the phenomenon of the overtraining syndrome. Moreover, as Egorov and Szabo (2013) have contended in relation to the sympathetic arousal hypothesis, the physiological effects of exercise should occur in everyone. Therefore, these models and theories do not explain why some individuals are at higher risk for exercise addiction than others.

Psychological Perspectives on Exercise Addiction

Among the various psychological explanations that have been offered for exercise addiction are the cognitive appraisal hypothesis and the affect regulation model. The disorder has also been explained within a behaviourist theoretical framework (Berczik et al., 2012), while, more recently, an interactional model of exercise addiction has been presented (Egorov & Szabo, 2013).

The cognitive appraisal hypothesis

According to the cognitive appraisal hypothesis, exercise addiction stems from a dependency on exercise as a means of coping with perceived stress (Berczik et al., 2012; Egorov & Szabo, 2013). When exercise is prevented or has to be reduced for any reason, adverse emotions emerge (withdrawal symptoms), and a key coping mechanism is lost. This stimulates perceptions of increased vulnerability to stress and fosters a focus on exercise at the expense of other commitments, triggering further stress. This creates a vicious circle where more exercise is needed to cope with mounting life stress that is partly caused by exercise itself (Berczik et al., 2012). However, this model is only able to explain the maintenance of exercise addiction and not its onset (Egorov & Szabo, 2013). More specifically, it is unable to account for the reason some individuals initially select exercise to manage stress, which involves considerable effort, as opposed to choosing another, more passive form of coping (Egorov & Szabo, 2013).

The concept of cognitive appraisal can be viewed within the context of transactional stress theory (Lazarus & Folkman, 1984), which has been described as the leading psychological stress model since the 1970s (Vollrath, 2001). According to this formulation, stress is an ongoing relationship between the person and the environment that is mediated by stress appraisal and coping processes (Vollrath, 2001). Cognitive appraisal refers to the evaluation of environmental demands with respect to one's well-being and available coping resources. Coping refers to the strategies that people use to manage both the demands of stressful situations and associated negative emotional reactions (Lazarus & Folkman, 1984).

Coping strategies may serve different functions. The aim of coping may be to manage or resolve stressful encounters (problem-focused) or regulate concomitant emotional distress (emotion-focused). Examples of emotion-focused forms of coping include denial, minimization, and repression (Lazarus & Folkman, 1984). Coping approaches may also be classified on an approach–avoidance dimension. This conceptualization differentiates coping strategies on the basis of whether attention is focused on or away from the source of stress and/or adverse emotional reactions, respectively (Suls & Fletcher, 1985). The use of exercise as a coping strategy could indicate a preference for an emotion-focused, avoidance coping style. It has been hypothesized that the constructs of 'intolerance of uncertainty' and 'intolerance of emotional arousal' explain the dispositional preference for vigilance or cognitive avoidance. Individuals who are unable to tolerate uncertainty are likely to employ vigilance or approach strategies, whereas those with a low tolerance for emotional arousal may tend to adopt avoidance strategies (Krohne, 1993). Therefore, the use of exercise as a coping strategy could indicate increased vulnerability to stress-induced emotional arousal.

The affect regulation model

The affect regulation hypothesis is based on a means–end model in terms of which exercise originally serves as a mechanism to avoid or reduce negative affect (Hamer, Karageorghis & Vlachopoulos, 2002). However, it has been posited that "the experience of needing to reduce negative affect without being able to exercise may then transform this relationship into a dependency" (Hamer et al., 2002, p. 234). Ultimately, the means takes preference over the end and relieving the distress associated with being unable to exercise becomes the main priority.

A behaviourist perspective

Berczik et al. (2012) have postulated that exercise addiction may also be understood within a behaviourist theoretical framework. According to behaviourist theory, reinforcement and punishment lie at the root of all human behaviour. Exercisers may be motivated by either positive or negative reinforcement. Positive reinforcement refers to behaviour that is directed towards obtaining a reward, such as feelings of mastery or satisfaction. Negative reinforcement describes actions that are aimed at avoiding negative or undesirable outcomes or experiences. It has been argued that negative reinforcement underlies exercise addiction. It is thought that addicted exercisers use exercise as a temporary means of escape from daily demands. When behaviour is negatively reinforced, "the person has to do it, as opposed to wants to do it" (Berczik et al., 2012, p. 411). The behaviourist approach to exercise addiction is supported by the contention that negative reinforcement can lead to compulsive behaviours that are highly resistant to change (Berczik et al., 2012). Consequently, the behaviourist approach to exercise addiction seems to provide a fairly compelling explanation for how the disorder could be maintained, but it does not really account for its onset.

An interactional model

Egorov and Szabo (2013) have recently presented an interactional model of exercise addiction that attempts to explain the adoption, maintenance, and transformation of exercise behaviour. This perspective expands on theories that suggest that addiction stems from the use of exercise as a coping strategy. This model is depicted in Figure 2.1.

According to this conceptualization, a complex set of personal and social-environmental factors – including personality, goals, abilities, and social values – interact to influence the initial motive for exercise behaviour. Motives may be related to health (physical/psychological), performance, and social factors, which may, in turn, have a therapeutic or mastery orientation. For example, health motives may include improving well-being or preventing ill health, which are both therapeutic goals. Alternatively, the aim of a health-motivated exerciser may be to gain strength and lift more weight, which can be described as a mastery orientation.

The sudden emergence of uncontrollable life stress, however, can trigger a reliance on exercise as a coping mechanism, increasing the risk for exercise addiction. Individual and situational factors as well as antecedents of exercise behaviour interact in the depicted 'black-box' to determine which individuals will choose this form of coping. This model states, though, that the use of exercise as a coping strategy is linked primarily to a therapeutic orientation. Unhealthy exercise patterns in mastery-oriented individuals are more likely to be due to factors like the non-acceptance of personal limits, excessive achievement striving, and a strong need to prove oneself in response to a previous failure. However, the exaggerated exercise behaviour that this elicits primarily reflects obsessive-compulsive symptomatology rather than addiction as it lacks the dependence element (Egorov & Szabo, 2013).

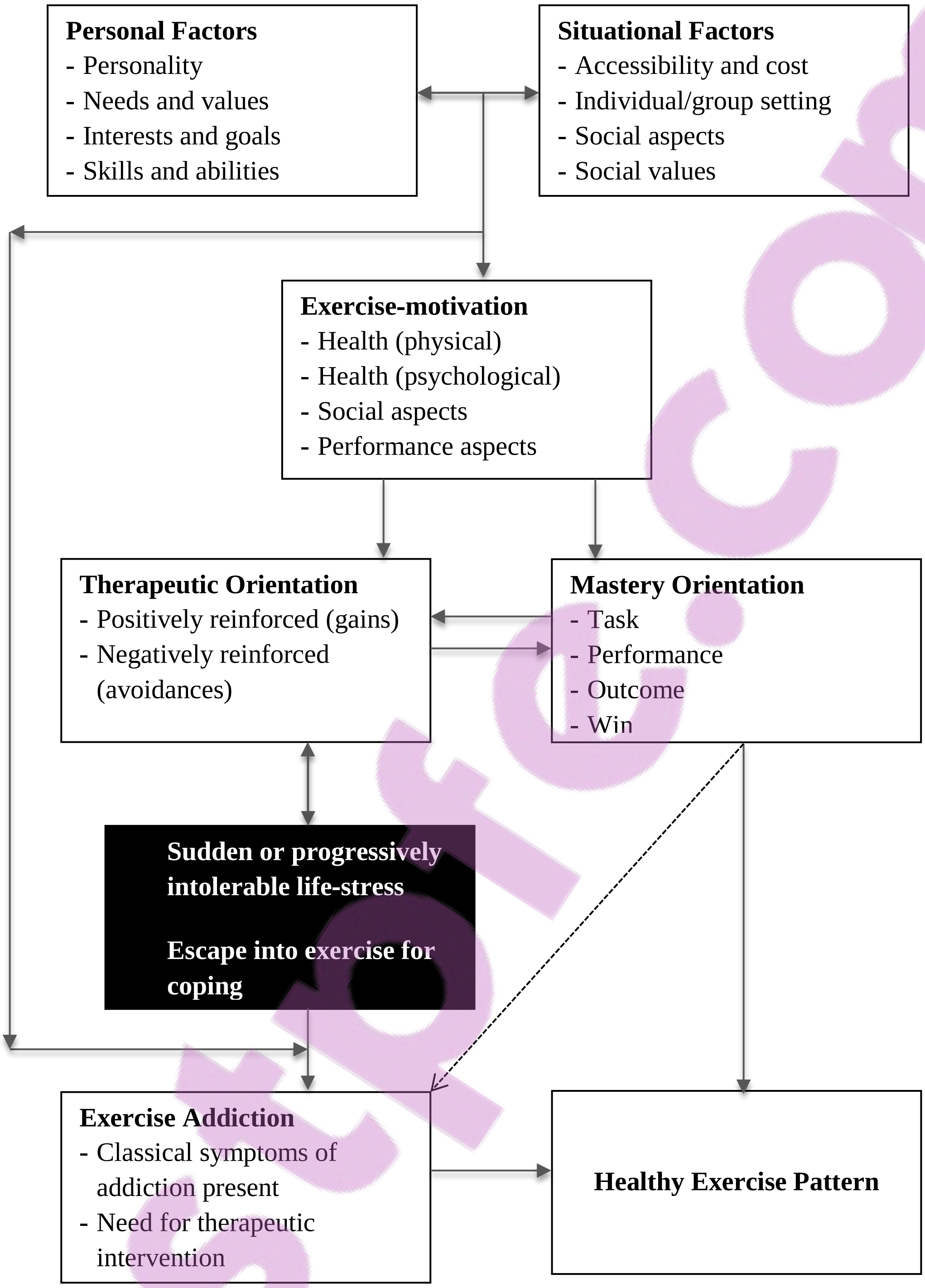

Figure 2.1. An Interactional Model of Exercise Addiction (Egorov & Szabo, 2013, p. 205)

Personality and Motivational Influences on Exercise Behaviour

The primary purpose of this section is to elucidate theoretical perspectives relating to potential personality and motivational influences on exercise addiction and training habits among endurance athletes. The personality traits of perfectionism and Type A behaviour pattern and the motivational construct of achievement goal orientations will constitute the main focus of this discussion.

Personality Traits and Exercise Behaviour

Egorov and Szabo's (2013) interactional model of exercise addiction indicates that a combination of factors, including personality variables, may influence the quality of the endurance athlete's exercise involvement. One of the personality traits that have frequently been investigated in relation to exercise addiction risk is perfectionism (Hagan & Hausenblas, 2003). The literature suggests that the personality disposition known as Type A behaviour pattern may also potentially contribute towards adaptive and maladaptive forms of exercise behaviour.

The trait approach to personality represents a dispositional conception of personality and may be contrasted with social-cognitive perspectives (Contrada & Goyal, 2008). The dispositional view of personality and the trait approach, in particular, has dominated the personality field (Contrada & Goyal, 2008). Currently, the five-factor (or 'big five') trait model is the most popular framework for understanding personality (Contrada & Goyal, 2008; Rhodes, 2014). This model describes personality in terms of five broad traits: extroversion, neuroticism, agreeableness, conscientiousness, and openness to experience (Contrada & Goyal, 2008; Rhodes, 2014).

Broadly-speaking, personality traits may be viewed as dispositions that describe stable individual differences in cognitive, emotional, and behavioural responses to the environment (Contrada & Goyal, 2008). Key characteristics of traits are their temporal stability and cross-situational consistency. This implies that traits are stable across time and context (Contrada & Goyal, 2008). Traits are also hierarchically organized, and broader and narrower traits may be distinguished. Each of the big five higher-order traits comprises a number of more narrowly-defined dispositions or facets. The big five traits may themselves cluster together to form a broader disposition, often referred to as a personality type (Contrada & Goyal, 2008). Research suggests that personality traits have a genetic basis and are not strongly related to parental rearing style (Rhodes, 2014). Traits may be distinguished from orientations or styles, which describe an individual's characteristic response to a specific set of circumstances, such as a competitive situation (Anshel, 2014).

Cockerill and Riddington (1996, p. 122) have noted that addicted exercisers seem to possess the following characteristics:

- Are dissatisfied with their body and/or themselves;
- Will exercise to have control, but have become controlled by the activity;
- Do not enjoy having free time;
- Have become dependent on the euphoric and calming benefits of exercise;
- Are avid goal-setters;
- Have become socially withdrawn.

Various psychological mechanisms could mediate the relationship between personality traits and potentially unhealthy exercise patterns. First, it has been argued that personality plays a key role in the stress process. Personality not only affects stress appraisal and coping but the selection and shaping of stressful situations (Vollrath, 2001). Studies have shown that certain personality traits, such as neuroticism, are also associated with higher levels of negative affect – both in the presence and absence of stress (Vollrath, 2001). Thus, some researchers have speculated that addicted exercisers who are high in neuroticism, for example, may use exercise as a maladaptive coping strategy (Hausenblas & Giacobbi, 2004). Certain personality dispositions may also promote dysfunctional patterns of cognition, which could, in turn, influence exercise behaviour. For example, narcissistic individuals may become preoccupied with exercise, believing that it provides a route to increased attention, admiration, and adoration (Hausenblas & Giacobbi, 2004).

It is plausible that perfectionism and the Type A behaviour pattern may influence dimensions of exercise participation via similar pathways to those cited above. A strong emphasis on exceptionally high personal standards of achievement characterizes both perfectionism and the Type A behaviour pattern (Flett, Hewitt, Blankstein & Dynin, 1994). Illusionary or unrealistically high goals are likely to generate increased stress (Vollrath, 2001). The propensity for perfectionists and Type As to experience greater stress exposure and to have poor coping mechanisms (Hewitt & Flett, 2002; Smith & Anderson, 1986) may compound perceptions of stress. In accordance with Egorov and Szabo's (2013) model of exercise addiction, when stress becomes overwhelming and/or uncontrollable, regular runners – especially those who exercise for therapeutic reasons – may turn to the activity as a means of managing adverse emotions. The cognitive appraisal hypothesis implies that exercise addiction risk is related to a dependence on exercise as a coping mechanism (Berczik et al., 2012; Egorov & Szabo, 2013).

Moreover, dysfunctional cognitions about the role of achievement in self-validation are inherent in definitions of both perfectionism and Type A behaviour (Ellis, 2002; Martin et al., 1989). These beliefs may, in turn, foster maladaptive achievement striving. Therefore, it is plausible that these personality dispositions could increase the risk for potentially unhealthy training patterns in distance runners. These ideas are discussed in greater detail below.

Perfectionism

Conceptualizations

Perfectionism has been defined as a multidimensional personality disposition that is characterized by very high personal standards and overly critical self-evaluations (Frost et al., 1990). Perfectionism may be more succinctly viewed as "the need to be first, best, perfect, and without any shortcomings, blemishes, or deficiencies" (Lombardi, Florentino & Lombardi, 1998, p. 61). From this perspective, it appears that perfectionism comprises a set of unrealistic standards and objectives and represents a maladaptive form of striving. The trait conceptualization of the construct implies that perfectionism may permeate a number of life domains, such as achievement, interpersonal relationships, and appearance (Flett & Hewitt, 2002).

Perfectionism was initially conceptualized as a unidimensional personality disposition (Stoeber, 2014a). However, an increased understanding of the construct has led to the consensus that perfectionism is a complex, multifaceted entity, comprising both personal and interpersonal aspects (Flett & Hewitt, 2005; Flett & Hewitt, 2002). One of the most prominent multidimensional approaches to perfectionism has been Frost et al.'s (1990) model, which defines perfectionism in terms of six independent yet related facets. These are high personal standards, concern over mistakes, doubts about actions, order and organization, parental expectations, and parental criticism.

The dimension of high personal standards in Frost et al.'s (1990) model reflects the tendency for perfectionists to select and strive to achieve extremely high standards and challenging goals. This facet of perfectionism has traditionally been regarded as central to the construct (Frost et al., 1990). However, it has been asserted that the dimension of concern over mistakes in performance is more critical to understanding perfectionism (Frost et al., 1990). This aspect of the trait describes the perfectionist's over-concern with and fear of making errors. It has been defined as "a tendency to have a negative reaction to mistakes, anticipate disapproval, and interpret mistakes as equivalent to failure" (Flett & Hewitt, 2002, p. 14). According to some researchers, this tendency mirrors the dichotomous thinking style of depressives. It reflects the belief that if one's performance is not flawless, then it is worthless (Frost et al., 1990). The doubts about actions component of Frost et al.'s (1990) model of perfectionism refers to the sense that one's performance is lacking in some respect or is of substandard quality. Phrases such as, "a feeling of uncertainty regarding an action or beliefs," and, "the sense that a job is not satisfactorily completed", have been used to describe this feature (Frost et al., 1990, p. 451). Perfectionism is also characterized by a desire for order, precision, and neatness in one's daily life. However, it has been maintained that this facet does not appear to be a core component of the construct (Frost et al., 1990).

The final two dimensions of perfectionism in Frost et al.'s (1990) model reflect the role of parental expectations and criticism in defining the construct and influencing its development. It has been posited that perfectionists' high standards and self-evaluations originate from their childhood experiences. It is thought that the parents of perfectionists were overly demanding and critical, and love and acceptance were conditional. In order to receive approval and avoid disapproval from significant others, the individual needs to perform at ever-increasing levels of perfection (Frost et al., 1990).

A further multidimensional conceptualization of perfectionism that has generated substantial research interest is a model that defines the construct in terms of three distinct facets (Stoeber, 2014b). These are self-oriented perfectionism, other-oriented perfectionism, and socially prescribed perfectionism (Stoeber, 2014b). In brief, self-oriented perfectionists strive for perfection and are highly self-critical, while other-oriented perfectionists expect perfection from others. Conversely, socially-prescribed perfectionists believe that others demand perfection from them (Stoeber, 2014b). The two different models of perfectionism have been described as complementary, and their different components are said to correspond in meaningful ways (Blankstein & Dunkley, 2002).

Lombardi et al. (1998) have described various negative behaviours and emotions associated with perfectionism. First, perfectionists will endeavour to excel and achieve at any cost, whether the cost is to themselves or others. Second, they tend to experience a sense of futility when unable to attain their high standards and are inclined to become apathetic. Third, perfectionists will try to conceal their shortcomings and mistakes through strategies such as making excuses, lying, and blaming others.

As already noted, perfectionism may be defined as the maladaptive combination of very high personal standards and harsh self-criticism. However, there appears to be increasing acceptance of a dual conceptualization of perfectionism among scholars in the field. Contemporary researchers typically distinguish two major forms of perfectionism – a positive, adaptive, or healthy form; and a negative, maladaptive, or unhealthy form. Some investigators have named these dimensions, perfectionistic strivings and perfectionistic concerns, respectively (Stoeber & Otto, 2006).

The adaptive or positive dimension is said to comprise those facets of perfectionism that are associated with healthy psychological adjustment, positive reinforcement, and approach tendencies. Conversely, the maladaptive or negative component is held to consist of those aspects of perfectionism that are linked to adjustment problems, negative reinforcement, and avoidance tendencies (Flett & Hewitt, 2002). Self-oriented achievement striving and the pursuit of high personal standards have been described as adaptive, whereas socially-prescribed perfectionism, self-criticism, and a fear of failure and negative evaluations by others are viewed as maladaptive (Flett & Hewitt, 2002; Stoeber, 2014a). It has been claimed that ‘positive perfectionists’, unlike ‘negative perfectionists’, have a flexible and realistic approach to achievement striving and are able to derive satisfaction from their efforts (Hagan & Hausenblas, 2003).

Processes and outcomes

Despite the contention that perfectionism has various positive or adaptive elements, some scholars believe that perfectionism should be viewed principally as a negative and self-defeating personality disposition. In examining the role of perfectionism in sport and exercise, Flett and Hewitt (2005) have stated that “perfectionism is primarily a negative factor that contributes to maladaptive outcomes among athletes and exercisers” (p. 14). It has also been suggested that dimensions of so-called positive perfectionism, such as high personal standards and organization, may simply reflect the broad personality disposition of conscientiousness rather than perfectionism as such (Flett & Hewitt, 2002). In any event, even the presumed adaptive aspects of perfectionism may produce adverse psychological reactions when negative life events or self-threatening ego-involving situations are experienced (Flett & Hewitt, 2002).

Researchers are increasingly recognizing the role of perfectionism in various kinds of psychopathology, including personality disorders, depression, anxiety, eating disorders, (Hewitt & Flett, 2002), addiction, neurosis, and suicide (Lombardi et al., 1998). Hewitt and Flett (2002) have highlighted the role of stress in this relationship.

These authors have argued that perfectionists are likely to experience a higher level of stress exposure and to cope poorly with stress, increasing the risk for adjustment problems. It has been posited that perfectionism is positively associated with the processes of stress generation, anticipation, perpetuation, and enhancement. This means that perfectionists are inclined to make choices, pursue goals, and engage in behaviours that can create stress in their lives (stress generation). Also, perfectionists are prone to expect stress or failure and to respond accordingly (stress anticipation). Further, such individuals tend to have self-defeating cognitive styles, such as rumination, self-blame, and overgeneralization of failure that can prolong and maintain perceived stress (stress perpetuation). Therefore, perfectionism may increase exposure to stress. Finally, maladaptive coping choices and ineffective coping strategies along with irrational cognitive responses to negative outcomes can magnify the impact of stressors (stress enhancement). According to Hewitt and Flett (2002), each of the above mechanisms could explain the relationship between perfectionism and psychopathology.

In order to manage adverse emotions, it is possible that perfectionistic runners may turn to exercise, which is readily accessible and has proven stress-moderating effects. Consistent with the tenets of the cognitive appraisal hypothesis, this strategy may increase the risk for exercise addiction (Berczik et al., 2012; Egorov & Szabo, 2013).

It has also been postulated that perfectionism is associated with a set of irrational cognitions in relation to the self (Ellis, 2002). For example, it has been asserted that perfectionism is linked to conditional self-acceptance and the belief that self-worth is contingent upon a high level of achievement, especially in comparison to others (Ellis, 2002). Among competitive distance runners, a combination of high personal standards, fear of failure, and a focus on self-validation may lead to a form of overstriving, manifesting in potentially unhealthy training patterns (Hall et al., 2007a).

Flett and Hewitt (2005) have identified a further mechanism whereby perfectionism may influence exercise behaviour. These authors have stated that some perfectionists are highly concerned with the image they present to other people. These self-presentation concerns may involve "striving to create a public image of flawlessness (i.e., perfectionistic self-promotion)" or attempts at "minimising one's mistakes (i.e., nondisplay or nondisclosure of imperfection)" (Flett & Hewitt, 2005, p. 16). An over-concern with factors like body image and public appearance may, in turn, foster an unhealthy preoccupation with exercise in an effort to facilitate impression management (Flett & Hewitt, 2005). Therefore, it seems that there are several pathways through which perfectionism could possibly influence quantitative and/or qualitative dimensions of exercise behaviour in distance runners.

Type A Behaviour Pattern

Conceptualizations

The Type A behaviour pattern has been defined as "a broad personality dimension involving a constellation of social cognition, affective, motivational, and behavioural factors" (Martin et al., 1989, p. 782). It has been conjectured that the Type A construct represents a distinctive combination of first-order traits, illustrated by low levels of agreeableness and high levels of extroversion, neuroticism, and conscientiousness (Rhodes, 2014). Typical Type A characteristics include aggressiveness, hostility, competitiveness, ambitiousness, impatience, and time urgency (Blumenthal et al., 1985; Fields et al., 1990; Smith & Anderson, 1986; Steinberg, 1985; Thoresen & Powell, 1992). Individuals exhibiting Type A behaviour are inclined to have extremely high personal standards and to exert great effort in all tasks, regardless of the specific task requirements (Ward & Eisler, 1987). The Type A behaviour pattern was first documented over 40 years ago in coronary patients and was identified as a major cause of coronary heart disease (Lee, Jamieson & Earley, 1996).

The Type A behaviour pattern has been conceptualized as a multidimensional construct consisting of three broad dimensions and a number of narrower facets. The set of characteristics that comprise the Type A construct can be broadly categorized as behavioural dispositions, overt behaviours, or emotional responses (Lee et al., 1996).

The dispositional dimension of the construct constitutes traits such as achievement-striving, ambitiousness, competitiveness, work involvement, and a hard-driving approach to tasks. These dispositions may manifest in various overt behaviours and psychomotor symptoms. These include time urgency, muscular tension, alertness, rapid and emphatic speech, impatience, and hyperactivity (Lee et al., 1996). The affective dimension of the construct comprises the different adverse emotional responses, such as hostility, anger, and irritability, that Type A individuals are prone to experience (Lee et al., 1996). In terms of performance and psychological and physical health outcomes, it has been proposed that the achievement-striving aspects of the construct are primarily adaptive, whereas the overt behavioural and emotional components are mainly maladaptive (Lee et al., 1996; Thoresen & Powell, 1992).

The opposite of the Type A behaviour pattern is Type B behaviour, which is characterized by easy-going, noncompetitive and nonaggressive behaviour (Lidor, 2014). Although Type Bs may be equally or more ambitious than Type As, the nature of their achievement striving is underpinned by positive as opposed to negative affect. Type B individuals experience confidence and satisfaction in relation to their efforts and accomplishments, whereas their Type A counterparts mainly experience anxiety and anger (Ward & Eisler, 1987).

Processes and outcomes

On the basis of the ambitious and hard-driving characteristics associated with the Type A behaviour pattern, it might be assumed that this construct mainly represents an adaptive achievement orientation. Although the achievement striving style of Type As may lead to success in some domains, this approach is generally likely to be maladaptive and associated with adverse outcomes (Ward & Eisler, 1987). In reinforcing this viewpoint, Martin et al. (1989) have described the Type A behaviour pattern as a personality variable that can have a negative impact on overall quality of life.

Certain theoretical models of Type A behaviour imply that a set of irrational beliefs underlie the construct. Guided by social cognitive theory, Martin and his colleagues (1989) have formulated a self-worth contingency model of the Type A behaviour pattern. According to this formulation, the overly-intense behaviours that characterize the Type A construct reflect a maladaptive coping style aimed at avoiding negative evaluations and maintaining a positive sense of self-worth. Type A individuals typically believe that self-worth is dependent upon their accomplishments, and they employ a set of unreasonable standards and rules to evaluate their performance. These tendencies, in turn, lead to excessive achievement striving and negative reactions, such as anger, when unable to meet achievement-related goals. Due to the unrealistic nature of these self-imposed performance standards, the risk of negative self-evaluations and adverse outcomes, such as perceived stress and depression, is increased. This model implies that Type A individuals are more likely to endorse emotion-focused coping strategies (Martin et al., 1989). The authors have suggested that social learning and sociocultural variables may interact with genetic factors to explain these maladaptive attitudes.

Other theoretical perspectives have highlighted the role of personal needs in Type A behaviour. Several theorists have postulated that a strong need for control over situations underlies the construct and motivates the characteristic Type A behaviours (Burnman et al., 1975; Lidor, 2014). The pronounced sense of time urgency and intense drive to succeed, which are core aspects of the construct, may be related to the need to master threatening aspects of the environment (Burnman et al., 1975). The time urgency component may reflect a fear of losing control, while feelings of hostility may be linked to a perceived loss of control (Lidor, 2014).

In contrast to a mechanistic unidirectional approach, as described above, some theorists have advocated a transactional understanding of the Type A construct. Smith and Anderson (1986) have emphasized the dynamic, reciprocal relationship that exists between the person and environment in facilitating and maintaining Type A behaviour. It has been proposed that Type A individuals do not simply respond to environmental stimuli but play an active role in creating challenging or stressful situations. These environmental factors, in turn, serve to elicit and reinforce the Type A behaviour pattern (Smith & Anderson, 1986).

In presenting a biopsychosocial interactional model of Type A behaviour and cardiovascular risk, Smith and Anderson (1986) have postulated that Type As actively construct a demanding environment in five primary ways. They tend to choose objectively difficult situations, to appraise these as stressful, to adopt maladaptive coping strategies, and to evaluate their performance in a negative light, prompting further intense striving. Also, the competitive and hostile nature of the Type A person's behaviour typically evokes negative responses from others. Therefore, the Type A individual is generally drawn to demanding situations. These environmental factors, in turn, elicit and sustain their characteristic hard-driving behaviour. This model implies that Type A behaviour may be related to increased psychosocial stress, interpersonal conflict, negative self-evaluations, and dysphoric mood (Martin et al., 1989).

The above theoretical perspectives suggest that Type A behaviour may influence training patterns among distance runners via at least two possible, related mechanisms. First, the drive to avoid negative evaluations and maintain a positive sense of self-worth via superior accomplishments may foster intense achievement striving, leading to potentially unhealthy training behaviours. Second, dysfunctional cognitions, combined with maladaptive coping strategies, greater interpersonal conflict, and increased exposure to challenging situations could serve to increase perceptions of stress. In this instance, the Type A runner – like the perfectionist – may select exercise as a coping strategy, which may, in turn, increase the risk for exercise addiction (Berczik et al., 2012; Egorov & Szabo, 2013).

Achievement Goals and Exercise Behaviour

The most popular motivation theory in sport and exercise psychology for the past few decades has been achievement goal theory (Roberts et al., 2007). Motivation, in turn, is a process that can be defined as the force that energizes and directs observable behaviour (Clews & Gross, 1995; Elliot & Zahn, 2008; Roberts et al., 2007). Therefore, motivation can be conceptualized as a causal agent (Elliot & Zahn, 2008). The energization and direction of behaviour can be described in terms of the ‘why’ and ‘how’ of action. Elliot and Zahn (2008) have defined the ‘why’ component as the underlying reason or impetus for a specific behaviour, while the ‘how’ dimension refers to the specific aim of action. Behaviour that is energized by and directed towards positive objects, events, and possibilities is termed approach motivation, whereas action that is energized by, and away from negative stimuli is called avoidance motivation (Elliot & Zahn, 2008). It has been postulated that motivation is a function of internal factors, such as inherited tendencies and affective and cognitive dispositions, as well as environmental factors, such as culture and socialization (Elliot & Zahn, 2008).

Achievement Goals: Conceptualizations

Achievement goals have been defined as “the aim, purpose, or focus of a person’s achievement behaviour” (Conroy & Hyde, 2014, p. 1). Achievement goal theory predicts that achievement goals affect a number of cognitive, affective, and behavioural processes and outcomes in achievement contexts (Conroy & Hyde, 2014). The achievement goal approach represents a social-cognitive conceptualization of motivation, which posits that behaviour is a function of a person’s interpretation of the social environment (Roberts et al., 2007). Achievement goal theory is based on the assumption that individuals are goal-directed and rational in their choice of actions (Roberts et al., 1998).

According to achievement goal theory, the main goal of behaviour in achievement contexts is to develop and/or demonstrate competence and/or to avoid demonstrating incompetence. Competence may have different meanings to different people. Essentially, it is held that two primary conceptions of competence or ability exist – an undifferentiated conception and a differentiated conception (Roberts et al., 2007).

It is posited that one’s specific conception of competence is a function of one’s personal theory of achievement, and it determines how one interprets success and failure (Roberts et al., 2007). When competence is undifferentiated, individuals do not make a distinction between ability and effort (Roberts et al, 2007). An undifferentiated conception of ability is characterized by the endorsement of task or mastery goals. In this context, competence is defined in terms of a general self-improvement motive, and the *development of* competence is key (Elliot & Thrash, 2001). When endorsing an undifferentiated conception of ability, competence is self-referenced or task-referenced (Roberts et al., 2007). This means that competence is evaluated in terms of how well one performs a task compared to previous performances or in relation to the attainment of mastery or understanding. These standards for evaluation are termed an intrapersonal standard and an absolute standard, respectively (Elliot & Thrash, 2001).

When competence is differentiated, achievement behaviour is characterized by the adoption of ego or performance goals (Roberts et al., 2007). In this case, competence is conceptualized in terms of a general self-presentation motive, and the *demonstration* of competence is paramount (Elliot & Thrash, 2001). When endorsing a differentiated conception of ability, competence is other-referenced (Roberts et al., 2007). This implies that competence is evaluated in terms of how well one performs a task in relation to others. The self-worth of ego-involved individuals is said to depend on outperforming others and not doing worse than others. This standard for evaluation is described as a normative standard (Elliot & Thrash, 2001).

According to Grant and Dweck (2003), three forms of ego or performance goals may be distinguished. Specifically, the purpose may be to validate one's ability (ability goals), outperform others (normative goals), or achieve a positive outcome (outcome goals). The significance of this distinction is that each type of goal may have different consequences in terms of impairment. It is expected that goals that are focused on the validation of ability are mainly dysfunctional. In contrast, normative goals and those that are focused on doing well on a specific task may lead to positive results. It seems that outcome goals may also be conceptualized within a task or mastery goal framework. However, the underlying reason for performance concerns may differ in that task goals may be focused on the development of competence and ego goals on the demonstration of competence (Grant & Dweck, 2003).

It has been postulated that early socialization experiences in the home or significant achievement contexts, such as the classroom, may predispose individuals to be task and/or ego involved. These predispositions are referred to as achievement goal orientations (Roberts et al., 2007; Roberts et al., 1998). Consistent with achievement goal theory, two achievement goal orientations, specifically task goal orientation and ego goal orientation, can be identified. A person's goal orientation has been defined more precisely as "one's typical state of achievement goal involvement over time within a particular context" (Conroy & Hyde, 2014, p. 1).

Achievement goal orientations should be viewed as cognitive schemas that guide achievement behaviour in sport and educational contexts (Roberts et al., 2007). Although achievement goals are dynamic and influenced by situational factors, goal orientations are characterized by a degree of temporal stability (Roberts et al., 2007). Notably, achievement goal theory assumes that dispositional goals orientations are orthogonal or independent. Therefore, individuals could exhibit both ego and task involving tendencies (Roberts et al., 2007; Roberts et al., 1998).

The task–ego goal distinction represents a dichotomous conceptualization of achievement goals. More recently, a hierarchical approach to achievement goals has been advocated (Elliot & Thrash, 2001). In brief, this formulation defines achievement goals not only in terms of the manner in which competence is defined, but on the basis of the 'valence' of the goal or striving (Elliot & Thrash, 2001). Valence refers to whether the aim of achievement behaviour is to attain a positive, desirable outcome or to avoid a negative, undesirable outcome. Goals that involve actively striving for competence are called approach goals, whereas those that involve striving away from incompetence are called avoidance goals.

The above conceptualization represents the formulation called the 2 × 2 achievement goal framework. According to this model, four kinds of achievement goals can be distinguished: mastery-approach, performance-approach, mastery-avoidance and performance-avoidance (Elliot & Thrash, 2001). Mastery-approach and performance-approach goals are equivalent to conceptions of task and ego goals in the dichotomous model (Roberts et al., 2007). Therefore, mastery-approach goals represent a striving for task mastery or improvement, while performance-approach goals involve the aim to outperform others. Performance-avoidance goals centre on not being outperformed by others. Mastery-avoidance goals focus on not making mistakes, performing worse than previously on a task or losing one's skills or abilities (Elliot & Thrash, 2001; Roberts et al., 2007).

Achievement Goals and Achievement Behaviour

Achievement goal theory predicts that task involvement is associated with adaptive achievement striving, whereas ego goal orientation is more likely to lead to maladaptive behaviour in achievement contexts (Elliott & Dweck, 1988; Roberts et al., 2007; Tenenbaum et al., 2005).

When the goal is to develop understanding and growth, individuals are likely to choose challenging goals, to invest effort, and to persevere in the face of difficulties (Roberts et al., 2007; Tenenbaum et al., 2005). Persons who are ego involved may also demonstrate adaptive achievement striving, although this is contingent upon perceived competence. High perceived ability evokes a sense of confidence that one can demonstrate ability and avoid displaying incompetence. This, in turn, is likely to encourage adaptive achievement behaviour (Roberts et al., 2007; Tenenbaum et al., 2005) but could also promote certain forms of risk avoidance (Elliott & Dweck, 1988). Conversely, when perceived ability is low, and it is unlikely that one can display one's competence, then maladaptive achievement striving is probable (Roberts et al., 2007; Tenenbaum et al., 2005). For example, ego involvement may lead to the avoidance of challenging tasks and reduced effort and perseverance in the presence of failure or setbacks (Roberts et al., 2007). When task goals are endorsed, on the other hand, perceived ability is not expected to be relevant (Elliott & Dweck, 1988). Also, task orientation is likely to be associated with increased competence as a result of the investment of energy and effort in undertakings (Tenenbaum et al., 2005).

Consistent with these ideas, in a study of obligatory exercise in distance runners, Hall et al. (2007a) theorized that since achievement is self-referenced and perceived to be within the individual's control when task goals are endorsed, this orientation is likely to be adaptive in athletic contexts. The authors maintained that task goals are likely to foster high levels of effort, and persistence in the face of obstacles or setbacks. Task goal orientation is also likely to promote flexible achievement striving as self-worth is not contingent upon achievement. This suggests that distance runners endorsing task goals may be inclined to train hard but within reasonable limits.

In contrast, Hall et al. (2007a) speculated that an ego goal orientation could lead to maladaptive achievement striving in distance runners. When ego goals are endorsed, “confirmation of who one is, what one can be or what one can do all become highly salient” (Hall et al., 2007a, p. 301). In this context, runners endorsing ego goals may exercise in unhealthy ways in order to enhance self-worth by obtaining positive judgements of ability or in an effort to protect or maintain self-worth by avoiding negative evaluations. This suggests that distance runners who are predominantly ego-oriented may be inclined to adopt heavy training loads and to persist with training despite injuries, illness, or other obligations.

With respect to the hierarchical model of achievement goals, it can be assumed that mastery-approach goals, which are equivalent to task goals in the dichotomous model, are typically adaptive. Performance approach goals, which are equivalent to ego goals, and mastery-avoidance goals are expected to produce mixed outcomes. However, performance-avoidance goals are liable to be mostly dysfunctional (Conroy & Hyde, 2014; Roberts et al., 2007).

Exercise Behaviour, Injuries, and URTIs

As discussed in the previous chapter, the role of exercise in health maintenance and disease prevention is widely recognized. Although traditionally regarded as health-enhancing, endurance exercise may, paradoxically, sometimes have detrimental effects on health (Khatri & Blumenthal, 2007). For example, overuse injuries are a well-known hazard of distance running (Noakes, 2001). It has also been postulated that chronic or acute heavy exercise may increase the risk of upper respiratory tract infections (Nieman, 2001). This section will focus on theories and models that provide insight into the effects of endurance exercise behaviour on susceptibility to running injuries and URTIs. First, however, an overview of contemporary models of disease will be provided in order to delineate the broad theoretical context of the research.

Contemporary Models of Disease

A model of disease can broadly be defined as a belief system about the causes of physical disorders (Engel, 1977). Scientific models are to be distinguished from popular or ‘folk’ models. The main purpose of scientific models is to guide research endeavours, whereas folk models are simply culturally-derived beliefs about disease that help promote social adaptation (Engel, 1977). Two contemporary models of disease in the Western world include the established medical or biomedical model and the relatively new, biopsychosocial model.

The Biomedical Model of Disease

The biomedical model of medicine has served as the predominant theoretical framework in the domain of disease prevention and health promotion in the Western world since the 19th century (Rohleder, 2012). The biomedical model also serves as the leading folk model of disease in modern Western society (Engel, 1977).

The medical or biomedical model of disease is based on the premise that all physical health disorders can be fully explained on the basis of measurable biological or natural phenomena. This model holds that physical disorders are caused by observable abnormalities in biochemical or neurophysiological processes (Engel, 1977). Health is conceptualized as the absence of disease, and treatment is aimed at the identified physical cause of the illness (Rohleder, 2012). The biomedical paradigm generally disregards the psychological and social dimensions of health and disease (Engel, 1977; Rohleder, 2012).

The biomedical approach has also been adopted in the field of psychiatry, where mental health problems are typically attributed to biological causes, and treatment is medically-based (Engel, 1977; Rohleder, 2012). For instance, it is assumed that factors like genetic predispositions, brain abnormalities, and neurotransmitter functioning are the source of mental disorders. Consequently, interventions generally consist of psychoactive drug therapy (Rohleder, 2012).

The biomedical model has made a significant contribution to the progression of medicine and health care. For example, this approach has led to major advances in surgical techniques and medical technology and to the development of vaccinations and antibiotics for the prevention and treatment of infectious diseases (Rohleder, 2012; Sarafino, 2008).

Nevertheless, the biomedical paradigm has several limitations, and 40-or-so-years ago this model was pronounced as, "no longer adequate for the scientific tasks and social responsibilities of either medicine or psychiatry" (Engel, 1977, p. 129). A primary criticism against the biomedical model is that it represents a dualistic conception of the mind and body, viewing the mental and physical as separate entities (Engel, 1977; Rohleder, 2012). The biomedical model is also reductionist, attempting to understand human health mainly on the basis of observable abnormalities at the biochemical and neurophysiological level (Engel, 1977; Rohleder, 2012). Reductionism is defined as "a philosophical point of view which maintains that complex phenomena are best understood by a componential analysis which breaks down the phenomena into their fundamental, elementary aspects" (Reber, 1995, p. 645). Therefore, the biomedical model ignores the role of psychological and social influences on illness and undermines the complexity of health and disease (Rohleder, 2012). It has been stated that the neglect of psychosocial contributions to disease "distorts perspectives and even interferes with patient care" (Engel, 1977, p. 131).

A further objection is that the biomedical model assumes that disease is not present in the absence of observable biochemical derangements (Engel, 1977). Thus, in theory, a patient who complains of being unwell but has no discernible somatic abnormalities would not be considered ill or receive treatment or care (Engel, 1977). The biomedical model has also been described as mechanistic in that it supposes that disease has a distinct biological cause and mode of treatment (Rohleder, 2012). Mechanism has been defined as "a philosophical doctrine that maintains that all events or phenomena, no matter their complexity, can ultimately be understood in a mechanistic framework" (Reber, 1995, p. 443). Mechanism is strongly related to determinism, which holds that all events have an identifiable cause (Reber, 1995). Finally, the biomedical model advocates treatment aimed at physical interventions, which may be harmful or intrusive (Rohleder, 2012).

The Biopsychosocial Model of Disease

In response to the limitations of the traditional biomedical model of disease, Engel (1977) proposed a new medical model that recognizes the complex nature of health and illness. This model is referred to as the biopsychosocial model of disease. The biopsychosocial paradigm underpins the disciplines of health psychology, psychosomatic medicine, and behavioural medicine, guiding research, training, and practice in these domains (Gallo & Luecken, 2008). Although the biopsychosocial model has largely become an accepted part of traditional medical education and care, the biomedical paradigm still predominates in modern Western medicine (Novack et al., 2007).

The biopsychosocial model expresses the belief that health and illness is a function of a complex interaction of biological, psychological/behavioural, and social/cultural/economic variables (Novack et al., 2007). Thus, this approach combines the biological, behavioural, and social sciences (Wiese-Bjornstal, 2010). According to the biopsychosocial paradigm, diverse individual (biological, psychological, behavioural) and environmental (biological/physical, social/cultural/economic) factors combine to initiate, maintain, and prevent disease. Some of the influences pertaining to the individual are genetic susceptibility, health-related behaviours, personality, emotions, stress, coping, and attitudes. Environmental influences include biological insults (carcinogens and pathogens), early childhood experiences, social networks, acute and chronic physical and psychosocial stressors, and socioeconomic status (Novack et al., 2007). Intervention and treatment strategies may, therefore, take place on a biological, psychological and/or social level.

The diathesis-stress theory represents an example of how biological and behavioural factors could interact to initiate illness or disease. According to this model, individuals may inherit a vulnerability (diathesis) to develop a specific disorder, which is then activated by an environmental/behavioural stressor (Barlow & Durand, 1999). When this genetic vulnerability is high, a low level of stress is needed to trigger the disorder. Conversely, a high level of stress is required to produce the disorder in the case of a low underlying vulnerability. For example, the regular drinker with ‘addictive’ genes is likely to have a higher risk of developing alcohol dependence than the habitual drinker without this inherited tendency (Barlow & Durand, 1999). The diathesis-stress model could arguably also apply to the occurrence of physical disorders. For instance, smokers who are highly susceptible to developing cancer may require few cigarettes daily over a short period of time to trigger the disease. In contrast, individuals with a low underlying inherited vulnerability may smoke excessively for decades without any ill effects.

The biopsychosocial model has several important strengths. First, it effectively addresses the growing shift in the type of health disorders experienced in the developed world during the 20th century. Specifically, the incidence of acute illnesses, such as pneumonia, has decreased, while chronic ‘diseases of lifestyle’ have markedly increased (Rohleder, 2012). For example, there has been a rise in disorders such as heart disease and cancer, which are associated with specific behavioural risk factors like substance use, poor diet, and lack of exercise. Second, the biopsychosocial model reflects the growing understanding that health is a state of physical, psychological, and social well-being and is not merely the absence of disease (Rohleder, 2012). Therefore, in comparison with the biomedical model, the biopsychosocial paradigm is arguably of greater practical and theoretical relevance in the present day and age.

Third, in understanding the aetiology, course, treatment, and prevention of health problems, the biopsychosocial paradigm considers the person in totality, rather than merely a specific aspect of his or her being.

Interactive approaches to sport and running injury risk

The merits of a biopsychosocial approach in advancing understanding of sports injury prevention, response, and recovery have also been recognized. In this respect, Wiese-Bjornstal (2010) has stated the following:

> "Examining literature from sports medicine, psychology, and sport science with a biopsychosocial view leads to a better understanding of the integrated nature of the mental and physical health of injured high-intensity athletes and best practices for psychological intervention, prevention and management efforts, effective recoveries, successful sport performance and healthy futures" (p. 108).

In advocating a biopsychosocial approach to injury in high-intensity sport, Wiese-Bjornstal (2010) has offered a model of injury risk that integrates a wide range of internal/intrinsic/personal and external/extrinsic/environmental factors (Wiese-Bjornstal, 2010). These variables represent the various exposures, choices, and hazards that, in combination, influence the athlete's risk of injury. According to this formulation, biological, psychological, physical, and sociocultural variables interact to affect susceptibility to sports injury. Biological influences include training protocols, body composition, health status, prior injury, fatigue, recovery status, and nutrition and hydration. Psychological risk factors comprise personality traits like perfectionism, as well as life event stress, coping resources, beliefs, goals, motives, and mood states, among other variables. Potential environmental influences on injury susceptibility include weather, equipment, and sport type and level, which are features of the physical environment, and social resources, pressures, coaching quality, and sport norms and ethics, which are components of the sociocultural environment.

Consistent with this perspective, it has been maintained that running injuries are generally the result of a combination of both predetermined and modifiable risk factors (Johnston et al., 2003; Noakes, 2001). This underscores the need for a holistic approach to injury prevention and treatment (Noakes & Granger; 2003). According to Noakes (2001), most injuries are the product of an interaction between genetic predispositions, training environment, and training methods. Factors that could influence running injury risk include training surfaces, training load, choice of running shoes, and the individual's unique physiological and biomechanical characteristics, such as muscle weaknesses, inflexibility, and various anatomical abnormalities (Johnston et al., 2003; Noakes & Granger, 2003).

Against this background, the section below will focus on theories and models that are relevant to understanding the effects of exercise addiction and training load on infectious illness and overuse injury risk in distance runners.

Stress-Related Perspectives on Exercise and Health

The assumed impact of qualitative and quantitative dimensions of exercise behaviour on injuries and URTIs in runners can be understood in relation to models and theories pertaining to the stress construct. Stress is a familiar concept in the field of psychology. However, stress is a biopsychosocial phenomenon and may be defined in biological/physical, psychological, or social terms (Hancock & Hancock, 2014). Stress may also be conceptualized as a cause and/or an effect.

Stress is often described as an adverse event or stressor that threatens homeostasis and elicits various physiological and behavioural responses (McEwen & Wingfield, 2003). Alternatively, stress may be understood in terms of the stress response itself. Therefore, stress may also be defined as a physiological or behavioural response to a psychosocial or physical/biological stressor (Collins, Sorocco, Haala, Miller & Lovallo, 2003). Approaches to stress that focus on causes, or stressors, are often termed stimulus-based models of stress, while those that centre on the effects of stressors on functioning are called response-based models of stress (Cox, 1978). These approaches are described in more detail below. A brief account of physiological stress response mechanisms is also provided, and various models of stress and health in sport and exercise are presented and discussed.

Stimulus-Based Models of Stress

Stimulus-based models of stress conceptualize stress as some type of demand that can adversely affect psychological, behavioural, and/or physiological functioning (Cox, 1978).

The source of the demand, or stressor, may be biological/physical, psychological, or social in nature (Hancock & Hancock, 2014). A stressor has been defined as any physical or mental challenge that threatens the body's ability to maintain homeostasis (Collins et al., 2003). In the context of sport and exercise participation, physical stressors include those factors that test the athlete's physiological adaptability, such as intense training (Hancock & Hancock, 2014). Physical stressors also include environmental threats, such as temperature extremes, intense noise, and high altitudes. Mental fatigue and competitive anxiety are examples of psychological stressors in sport and exercise, while perceived expectations of others constitute socially-based sources of potential stress (Hancock & Hancock, 2014).

The stimulus-based approach to stress has been described as an engineering model of stress in that it draws an analogy between people and physical systems (Cox, 1978). According to Hooke's law of elasticity, any stress place on a machine will cause deformation or strain until the load is removed. However, permanent damage may occur if the strain exceeds the metal's elastic limit (Cox, 1978). In the same way, when environmental demands exceed the individual's stress tolerance levels, the resulting strain may lead to physiological and/or psychological dysfunction.

Consistent with these ideas, some scholars have described training stress as a mechanical load that is applied to the human body (Bredeweg, Zijlstra & Buist, 2010). An excessive level of applied stress may weaken the tissues of the musculoskeletal system, increasing the risk for overuse injury. In a similar vein, it has been asserted that overuse injuries "are a result of chronic, accumulated stress on the musculoskeletal system" (Khatri & Blumenthal, 2007, p. 985). Other researchers have argued that a running injury indicates that the body is unable to adapt to the imposed training load (Noakes & Granger, 2003).

Response-Based Models of Stress: Selye's Physiological Stress Theory

The physiological theory of stress proposed by stress researcher and physician, Hans Selye, is probably the most well-known of the response-based models. Selye (1975) viewed stress as a biological concept, defining it as the body's nonspecific response to any "increased demand for readjustment, for performance of adaptive functions which re-establish normalcy" (p. 2140). This theory implies that the body's reaction to disruptions in homeostasis is always the same, regardless of the nature of the stressor.

Selye (1975) developed his theory of stress after observing that cattle injected with a new ovarian hormone displayed a uniform pattern of bodily responses. It was soon found that other toxic substances, as well as stimuli such as heat, cold, infection, trauma, and nervous irritation, evoked the same set of physiological changes. From these observations, Selye deduced that the body reacted in a stereotypical manner to any increased demand for action or adjustment. This defensive response was termed the 'general adaptation syndrome', and the word, 'stressor', was used to refer to stress-inducing stimuli.

Selye (1975) theorized that with continued stressor exposure, three distinct phases to the generalized stress response could be identified: an alarm reaction, a stage of resistance, and a stage of exhaustion. The alarm reaction has been described as the mobilization or a 'calling to arms' of the body's defences. During this stage, the hypothalamus secretes a chemical messenger that elicits the release of adrenocorticotropic hormone from the pituitary gland into the bloodstream. This causes the outer part of the adrenal gland, the adrenal cortex, to secrete the glucocorticoid, cortisol, into circulation. Cortisol, in turn, causes a number of bodily changes, including shrinkage of the thymus, atrophy of the lymph nodes, reduced inflammation, and increased sugar production.

The alarm phase is marked by decreased resistance to the noxious agent. With repeated exposure, however, the body adapts to the demand, and its defensive abilities are increased. General physiological arousal also subsides. Unlike the catabolic or energy-releasing changes marking the alarm stage, the stage of resistance is characterized by anabolic or energy-conserving events. Extended exposure to a stressor may, however, eventually exhaust the body's finite resources, triggering a return to the alarm phase. Although signs marking the alarm reaction may now be chronic, sleep and rest may partially restore the body's adaptation energy. This may allow the organism to develop some resistance to the offending stimulus.

The tenets of the general adaptation syndrome theory imply that either short- or long-term exposure to intense physical training stress could have harmful consequences. For example, a bout of intense exercise is likely to elicit physiological changes characteristic of an alarm reaction. During this transient weakened state, it is plausible that athletes may be more susceptible to adverse training effects like fatigue, injuries, and illness. This period may last between one and seven days (Keizer, 1998). However, termination of the stress response allows the body to adapt to the stressor, and function is improved (Keizer, 1998; O'Toole, 1998). This stage is marked by heightened defences and enhanced functioning.

An extended period of heavy exercise, though, may ultimately exhaust the body's limited adaptive reserves, resulting in more severe and persistent physiological impairment. This stage of exhaustion seems to effectively describe the overtraining syndrome, which has been attributed to the body's inability to adapt to the psychophysiological demands of prolonged intense training and competition (Adams & Kirkby, 2001; McKenzie, 1999; O'Toole, 1998).

As noted earlier, the deleterious state of maladaptation or physiological breakdown characteristic of the overtraining syndrome is marked by impaired performance; chronic fatigue; psychological, hormonal and immunological disturbance; and increased susceptibility to overuse injuries and infectious illness (Adams & Kirkby, 2001; Kellmann & Altfeld, 2014a; Mackinnon, 2000; McKenzie, 1999; Meeusen et al., 2010). Due to their propensity to train frequently and without limitations, addicted exercisers may be especially vulnerable to overtraining and its effects (Adams & Kirkby, 2001). Therefore, the overtraining syndrome may serve as a mechanism whereby exercise addiction could increase distance runners' susceptibility to injuries and infectious illness. It has been proposed that concomitant psychosocial stressors could also increase the potential for negative training adaptations (Appaneal & Perna, 2014; Keizer, 1998; Kellmann & Altfeld, 2014a; Mackinnon, 2000; Meehan et al., 2002; Meeusen et al., 2010).

The general adaptation syndrome theory explains in broad terms how physical/biological, psychological, and/or social stressors influence physiological functioning and consequently, may affect health outcomes. A more detailed description of the body's physiological stress response mechanisms may facilitate understanding of how exercise addiction and heavy training loads could increase susceptibility to running injuries and infectious illness. This is discussed next.

The Physiological Stress Response

The body's physiological response to stress is a complex process. Since a comprehensive discussion is beyond the scope of this chapter, a synopsis that includes key points will be provided. In short, regardless of their nature, stressors activate the body's two major stress response systems: the hypothalamic-pituitary-adrenal-cortical axis and the sympathetic adrenal medullary axis (Clow, 2001). The function of the stress response is to restore stress-disturbed bodily homeostasis (Collins et al., 2003).

Activation of the major stress pathways is associated with the secretion of glucocorticoids (e.g., cortisol) and catecholamines like norepinephrine and epinephrine (Gotovtseva et al., 1998). These substances regulate the activity of a number of bodily systems and organs (Clow, 2001). For example, epinephrine and norepinephrine prepare the body for a fight or flight response. Thus, heart rate is raised, blood vessels are narrowed, and blood flow to the brain and skeletal muscles is increased. Simultaneously, the blood supply to the kidneys, skin, and digestive system is reduced (Clow, 2001). Among other functions, cortisol promotes the release of glycogen from the liver and muscles, and stimulates the liberation of stored fats and proteins. This, in turn, increases the amount of available energy (Clow, 2001).

Of significance in the context of infectious illness risk, cortisol is able to bind with immune cells and modulate the functioning of the immune system (Clow, 2001; Gotovtseva et al., 1998). Similarly, the catecholamines released during stress can affect immune organs and cells either via the bloodstream or through direct contact with immune tissue (Appaneal & Perna, 2014). The immune system is the body's defence against foreign organisms or substances, called antigens, and its primary function is to distinguish self from non-self (*Dorland's Illustrated Medical Dictionary*, 1994).

Exercise scientists have estimated that immunosuppressive effects induced by intense physical exertion can last from three to 72 hours (Nieman, 2001). According to the 'open window' theory of exercise and infection, this transient period of impaired immune function may provide pathogens with an opportunity to invade the system, thus increasing the risk for viral infections (Nieman, 2001). If individuals undertake a new bout of intense exercise before their immune systems have recovered, then chronic immunosuppression may result (Pedersen et al., 1996). This suggests that acute and/or chronic heavy exercise may increase runners' susceptibility to URTIs.

Aside from regulating immunity, prolonged elevations in cortisol levels may influence skeletal muscle growth and tissue repair mechanisms following acute intense exercise (Appaneal & Perna, 2014). For example, cortisol may impede secretions of anabolic factors, such as growth hormone and insulin-like growth substances, thus potentially impairing muscle repair ability. Therefore, chronic training-induced cortisol elevations may also have harmful implications for distance runners' susceptibility to overuse injuries (Appaneal & Perna, 2014).

In contrast to the adverse physiological changes associated with acute and chronic heavy exercise, regular moderate aerobic training may elicit increased secretions of immunoenhancing factors, such as cytokines, prolactin, and growth hormone (Mackinnon, 1994). Consequently, researchers have devised a J-shaped model of exercise and infection (Nieman, 2001). According to this formulation, chronic excessive exercise increases URTI risk, whereas regular exercise of moderate intensity and duration is protective against the common cold and influenza. In terms of URTI susceptibility, this model theorizes that heavy exercisers are most at risk, followed by sedentary individuals, while moderately active persons have the lowest risk of infection.

Models of Stress and Health in Sport and Exercise

Various biopsychosocial perspectives on stress and health in sport and exercise underscore the complex nature of the training–illness/injury relationship. These approaches include Mackinnon's (1994) theoretical model of stress, exercise, illness, and immune function; the classic stress and athletic injury model of Andersen and Williams (1988); and the recent biopsychosocial model of stress and athletic injury and health, offered by Appaneal and Perna (2014).

Mackinnon's (1994) immune-focused model posits that a complex set of interrelationships exist between psychosocial stress, exercise behaviour, illness, and the immune system. In this model, psychosocial stress, illness, and exercise patterns are depicted as three points on a triangle, with the immune system occupying a central position within the triangle. It is postulated that bidirectional relationships exist between stress, exercise, and illness, thus suggesting that these variables are mutually-influencing. For example, both exercise and stress can influence susceptibility to illness, while illness can affect the capacity for exercise. Furthermore, each component of the triangle can exert independent and/or interaction effects on the immune system. The strength of this model is that it highlights the interactions that exist among stress, exercise, illness, and the immune system. However, it could be argued that the single-headed arrow linking illness to the immune system could be replaced by a bidirectional arrow to indicate a mutually-influencing relationship between these two factors.

One of the most influential psychosocial models of athletic injury is Andersen and Williams's (1988) interactional stress and injury model. It has so far served as the theoretical basis for much of the research performed in this area (Williams & Andersen, 2007). At the core of this model is the stress response, which comprises cognitive, physiological, and attentional elements.

The authors have hypothesized that a person's history of psychosocial stressors, coping resources, and personality characteristics independently or in combination influence the stress response – with subsequent implications for injury risk. Psychosocial stressors include life event stress, daily hassles, and previous injury, while coping resources comprise variables like coping behaviours, social support, and stress management. Personality factors that may modify the stress response include hardiness, locus of control, sense of coherence, achievement motivation, and competitive trait anxiety.

The stress–injury model proposes that injury risk is increased when participants appraise training or competition related demands as stressful, resulting in adverse physiological and attentional changes. Reactions to positive stress appraisals include increased generalized muscle tension, distractibility, and narrowing of the visual field. It is maintained that these components of the stress response primarily mediate the psychosocial stress–injury relationship in athletes.

The primary value of Andersen and William's stress–injury model appears to lie in its ability to explain traumatic or acute injury rather than chronic or overuse injury (Williams & Andersen, 2007). Also, this formulation focuses on cognitive evaluations of athletic-related demands and does not consider the impact of physical training stress on health outcomes.

Appaneal and Perna (2014) have recently presented an independent, expanded version of Andersen and Williams's (1988) classic conceptualization of the stress–injury relationship. This model is pictured in Figure 2.2. Unlike its predecessor, the adapted formulation considers the interaction effects of intense physical training and psychosocial stress on health outcomes. Further, the model is able to explain overuse injury and also includes stress-related adverse health consequences beyond injury.

The core tenet of Appaneal and Perna's (2014) model is that intense physical training influences illness and injury risk in conjunction with negative life event stress. Further, the relationship between stressors and health outcomes is mediated by various physiological and behavioural mechanisms. It is posited that psychophysiological stressors elicit adverse physiological changes, such as immunosuppression and impaired skeletal muscle repair ability. Psychophysiological stressors can also have deleterious effects on sleep patterns, self-care, and treatment compliance, which can, in turn, influence physiological stress response mechanisms. The physiological and behavioural reactions to physical and psychosocial demands may have several adverse health consequences. These include increased susceptibility to injury and infectious illness, extended injury recovery time, and a greater risk of training maladaptation.

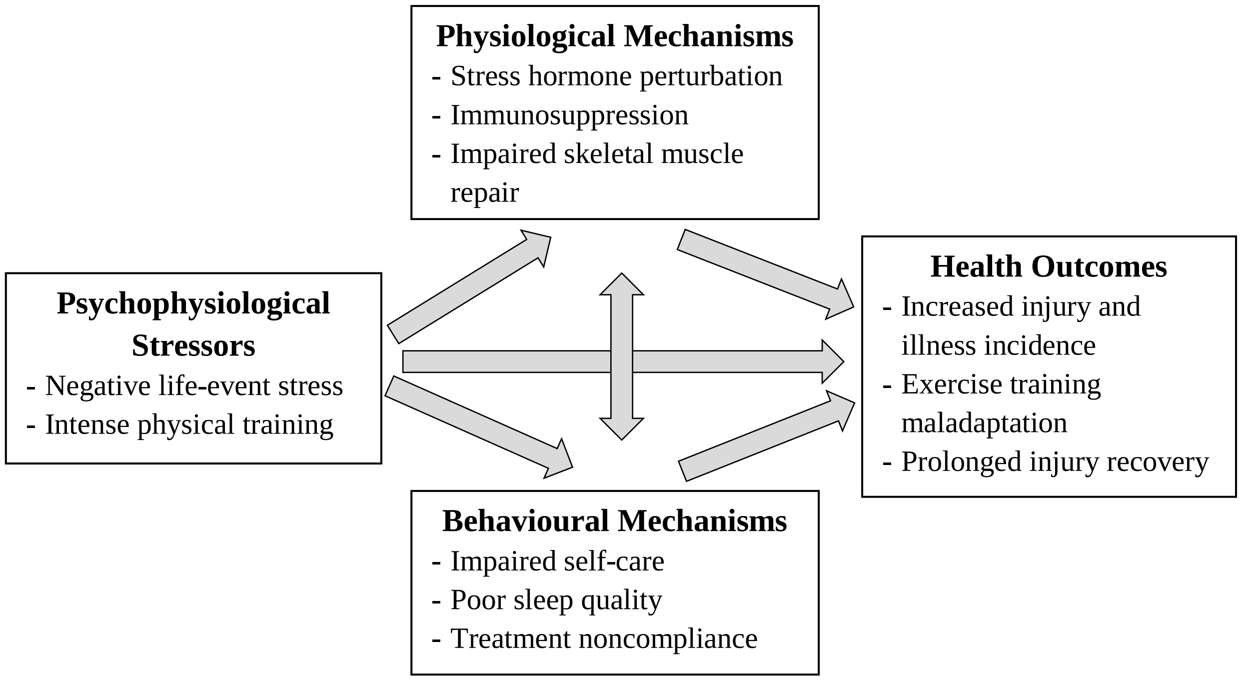

Figure 2.2. A Biopsychosocial Model of Stress and Athletic Injury and Health (Appaneal & Perna, 2014, p. 74)

Summary and Conclusions

The main purpose of this chapter was to place the present study in a theoretical context. As part of this objective, the concept of exercise addiction was examined in some depth, while theoretical perspectives pertaining to possible psychological influences on exercise behaviour were also reviewed. The personality traits of perfectionism and Type A behaviour pattern, and the motivational construct of achievement goal orientations constituted the primary focus of this discussion. Various theoretical approaches concerning the impact of exercise addiction and training load on URTIs and overuse injuries were also presented. Specific attention was given to the role of stress-related processes and mechanisms in these relationships.

With regard to personality and motivational influences on potentially harmful aspects of exercise behaviour, the literature suggests that perfectionism, Type A behaviour, and achievement goal orientations have the capacity to influence exercise addiction risk and/or training habits in distance runners. It seems that perfectionism, Type A behaviour, and ego goal orientation may foster excessive achievement striving in a bid to avoid negative evaluations and promote self-worth. This may, in turn, promote the adoption of unhealthy training patterns, marked by overly-strenuous training regimens and compulsive forms of exercising. Task goals, which are focused on improvement and mastery, are expected to encourage a highly motivated yet flexible approach to running, which may reflect in challenging yet not inherently pathological exercise routines. Additionally, it is plausible that the use of running as a means of escaping from uncontrollable psychological stress may mediate the effects of perfectionism and Type A behaviour on exercise addiction risk in distance runners.

Based on the information presented, it may be concluded that chronic heavy endurance training and/or dysfunctional training patterns associated with exercise addiction may increase the risk for URTIs and overuse injuries among distance runners. These effects are likely to be mediated mainly by adverse changes in immune function and muscle repair mechanisms induced by prolonged exposure to physical training stress. Furthermore, psychosocial stress could exacerbate the negative effects of intense training on injury and illness. The following chapter will comprise a review of the available research literature that is relevant to the current investigation.

CHAPTER 3

REVIEW OF THE EMPIRICAL LITERATURE

Introduction

The primary purpose of this chapter is to present and critically evaluate previous empirical research relating to the present study. In accordance with this objective, this section will focus on the following key issues: (1) the impact of perfectionism, Type A behaviour pattern, and achievement goal orientations on qualitative and quantitative dimensions of exercise behaviour and (2) the effects of exercise addiction and training factors on injuries and infectious illness in distance runners. The discussion will proceed from a broad view of the problem to a more narrow perspective. Therefore, studies that are of more general relevance will be addressed prior to research that is central to the current investigation. First, however, the main methodologies used in exercise addiction studies and in research examining exercise behavioural influences on overuse injuries and URTIs will be briefly described and evaluated.

Research Methodologies in Exercise Research

Exercise Addiction Studies

Most studies of exercise addiction and related constructs have been purely quantitative in nature (Hausenblas & Downs, 2002b; Johnston et al., 2011). Qualitative investigations, such as in-depth interviews and case studies, have been performed less frequently (Hausenblas & Downs, 2002b). Exercise addiction research has also been characterized predominantly by correlational designs, which prohibit causal interpretations, and by the use of self-report methodologies.

Various operational definitions of exercise addiction have been employed. For example, some researchers have defined the construct in quantitative terms. In these studies, factors such as training frequency, intensity and/or duration, or the number of years exercising have been used to assess compulsive forms of exercise behaviour (Hausenblas & Downs, 2002a; 2002b). In some cases, therefore, exercise addiction studies may be useful in understanding the antecedents and consequences of training load. The measurement of observable training characteristics reflects a unidimensional approach to the assessment of exercise addiction. Unidimensional definitions of the construct have also been physiological or psychosocial in nature (Hausenblas & Downs, 2002b).

Several exercise addiction measures that assess either single or multiple dimensions of the concept have been developed. Unidimensional instruments include the Obligatory Exercise Questionnaire, Negative Addiction Scale, and Commitment to Running Scale. A limitation of these tools, however, is that they provide an incomplete assessment of the construct (Downs & Hausenblas, 2014). In recognition of the multifaceted nature of the condition, multidimensional self-report questionnaires, such as the psychometrically-validated Exercise Dependence Scale and Exercise Addiction Inventory, are currently widely used in exercise addiction research (Berczik et al., 2012). These scales are not diagnostic tools but are simply screening measures that identify individuals at risk for exercise addiction (Egorov & Szabo, 2013).

Overuse Injury and URTI Research

According to reviews of the literature, various types of research designs and methodologies have been employed in studies assessing the effects of exercise on overuse injuries and infectious illness. These investigations have mainly included retrospective or prospective cohort studies, cross-sectional studies, case-control studies, or randomized, controlled trials (Moreira et al., 2009; Nielsen et al., 2012; van Gent et al., 2007).

Retrospective and prospective research designs differ in terms of the scheduling of assessments. In retrospective or post-URTI/injury research designs, the predictor and outcome variables are measured concurrently (Petrie & Falkstein, 1998). In prospective studies, the predictor variables are measured first, and the outcome variables are assessed over the course of the study or at the end of the research. Prospective designs usually enable more accurate interpretations about possible cause and effect relationships (Petrie & Falkstein, 1998). When retrospective designs are used, the temporal ordering of events is less clear. For example, when recent training behaviours and injury occurrences are assessed simultaneously, the respective predictor and outcome variables are indeterminable.

The literature indicates that a wide variety of populations have been assessed in studies of exercise behaviour and overuse injury or infectious illness risk. Participants have included members of the general population and various subgroups of endurance athletes, including elite and recreational swimmers, triathletes, cyclists, and rowers (Shephard & Shek, 1999, Moreira et al., 2009). However, many of the more comprehensive studies in this field have involved distance runners (Shephard & Shek, 1999). This population has, in turn, comprised individuals of diverse ability and experience levels, ranging from novice runners to recreational and elite marathon runners (Nielsen et al., 2012; Ryan et al., 2006; van Gent et al., 2007).

Most studies in this domain have used self-report methods, such as questionnaires or running diaries, to collect exercise and/or health-related data (Moreira et al., 2009; Nielsen et al., 2012). A limitation of self-reports of training, injuries, or infectious symptoms is the problem of recall bias, which may lead to inaccurate information (Nielsen et al., 2012). It has been argued, however, that athletes are usually highly attentive to health problems and many keep detailed training logs (Konig, Northoff & Berg, 2002). These habits may improve the reliability of self-report methods in this population. A few investigators have utilized intervention measures to assess exercise exposure (Nielsen et al., 2012). Other methods of assessing URTIs have included clinical evaluations or retrospective analyses of participants' medical records (Moreira et al., 2009). Occasionally, objective techniques, such as radiological or physiological testing, have been used to measure running-related injuries.

It is evident that an array of running injury definitions has been adopted across investigations. In most studies, however, running injuries have been operationally defined in terms of self-reported injury-related training stoppages or restrictions for one or more days (Nielsen et al., 2012; Petrie & Falkstein, 1998; Ryan et al., 2006). Other injury definitions have included self-reported pain during or after running, or clinically-diagnosed musculoskeletal running-related disorders (Nielsen et al., 2012; Ryan et al., 2006). In some cases, more objective definitions of injury have been employed based on blood test results (Dressendorffer & Wade, 1983) or imaging techniques (Schueller-Weidekamm et al., 2006).

Operational definitions of URTI have typically comprised self-reported incidence and/or duration of one or more infectious symptoms, such as sore throat, nasal congestion, cough, or fever. In a minority of cases, URTIs have been clinically diagnosed. Although clinically-assessed URTIs may be more reliable than self-reports, experience has shown that self-diagnoses of infectious illness are generally accurate (Konig et al., 2002). It has been demonstrated that self-report health assessments also have good construct and predictive validity (Molnar, Reker, Culp, Sadava & DeCourville, 2006).

Personality and Exercise Behaviour: The Research

A wealth of research over the past few decades indicates that personality traits play a key role in actions and behaviour, including physical activity (Rhodes, 2014). Personality dispositions have been shown to affect exercise participation, maintenance, mode, and level (Rhodes, 2014). Although research examining the role of personality traits in the aetiology of exercise addiction is relatively scarce (Hausenblas & Giacobbi, 2004), these studies have demonstrated that personality dispositions may be important predictors of potentially harmful exercise behaviour (Basson, 2001; Downs et al., 2004; Gulker et al., Hagan & Hausenblas, 2003; Hall et al., 2007a; 2007b; 2009; Hausenblas & Giacobbi, 2004; Hill et al., 2015; Lichtenstein et al., 2014; Miller & Mesagno, 2014; Taranis & Meyer, 2010). This research is consistent with observations that personality variables may influence the risk for addictive disorders in the general population (Zuckerman, 2012).

Researchers investigating personality risk factors for exercise addiction and related constructs have examined both broad and narrower traits. Hausenblas and Giacobbi (2004) assessed associations between the big five personality dimensions and exercise addiction in a large pool of university students. Exercise addiction symptoms were associated with high neuroticism and extroversion and low agreeableness. High neuroticism and low agreeableness have also been observed in relation to substance abuse disorders (Zuckerman, 2012). A subsequent investigation confirmed the finding that exercise addicted and non-addicted individuals differ in levels of extroversion and agreeableness (Lichtenstein et al., 2014). Levels of excitement-seeking, activity, hostility, and achievement striving were also significantly higher in exercisers with indications of addiction in this study. In other research, exercise-addicted and non-addicted students did not differ significantly in extroversion, although the sample size was small ($N = 24$) (Mathers & Walker, 1999). Exercise addiction in regular exercisers has also been positively related to narcissism (Miller & Mesagno, 2014) and obsessive-compulsive symptomatology (Gulker et al., 2001). Another study, though, did not detect an association between exercise addiction and obsessive-compulsiveness (Iannos & Tiggemann, 1997). Thus, there seems to be conflicting evidence for this relationship. There were also no significant differences between addicted and non-addicted exercisers on measures of self-esteem or locus of control in the latter investigation.

South African studies have demonstrated that runners with high addiction scores tend to exhibit rigid and inflexible personality patterns in comparison with low-scoring runners (Basson, 2001). However, it was noted that personality variables only accounted for a small proportion of the variance in exercise addiction in this body of research. It was also found that runners with symptoms of addiction displayed no specific personality pathology, although there was evidence of interpersonal difficulties in these individuals. A limitation of this set of studies was the use of a unidimensional rather than a multidimensional measure of running addiction.

It has been posited that stress may mediate the relationship between personality factors and exercise addiction (Hausenblas & Giacobbi, 2004). For example, persons high in neuroticism may use exercise as a maladaptive means of coping with stress and anxiety. In support of the role of stress in exercise addiction, a qualitative study noted that gym members classified as addicted to exercise reported using exercise as a coping strategy and as a means to express adverse emotions like anger and anxiety (Warner & Griffiths, 2006). In contrast, committed exercisers were motivated by health and competition factors.

Perfectionism: Correlates and Consequences

It is generally accepted that perfectionism is a complex, multifaceted personality trait, comprising both intrapersonal and interpersonal aspects (Flett & Hewitt, 2005; Flett & Hewitt, 2002). Researchers have proposed that a positive, adaptive, or healthy form and a negative, maladaptive, or unhealthy form of perfectionism can be distinguished. It is believed that each of these dimensions – alternatively termed perfectionistic strivings and perfectionistic concerns, respectively – have different psychological correlates and outcomes (Flett & Hewitt, 2002; Stoeber, 2014a). However, some authors have maintained that perfectionism is, in general, primarily a negative and self-defeating personality disposition (Flett & Hewitt, 2005).

A number of studies support the potential destructiveness of perfectionism. In general population research, perfectionism has been positively associated with stress, burnout (D'Souza, Egan & Rees, 2011), procrastination, depression, psychopathology (Frost et al., 1990), suicidal ideation (Flett, Hewitt & Heisel, 2014), and musculoskeletal disorders (van Eijsden-Besseling, Peeters, Reijnen & de Bie, 2004).

It has also consistently been demonstrated that dimensions of positive perfectionism primarily predict adaptive cognitions, emotions, behaviours, and outcomes. For example, perfectionistic strivings has been positively related to challenge appraisals, active coping (Stoeber & Rennert, 2008), positive affect, and physical health (Molnar et al., 2006). Inverse associations have been observed between adaptive perfectionism and threat and loss appraisals, avoidant coping, burnout (Stoeber & Rennert, 2008), perceived stress (Achtziger & Bayer, 2013), and negative affect (Molnar et al., 2006).

Conversely, perfectionistic concerns has been positively related to threat and loss appraisals, avoidance coping (Stoeber & Rennert, 2008), perceived stress (Achtziger & Bayer, 2013; Tashman, Tenenbaum & Eklund, 2010), negative affect (Molnar et al., 2006), and burnout (Stoeber & Rennert, 2008; Tashman et al., 2010). Negative associations have been reported between maladaptive perfectionism and challenge appraisals, active coping (Stoeber & Rennert, 2008), positive affect, and physical health (Molnar et al., 2006).

Research conducted in sport and exercise contexts suggests that perfectionism may influence motivation, behaviours, and outcomes in these domains. For example, perfectionism predicted relative autonomy and self-presentation tendencies, which were positively related to exercise behaviour in college students (Longbottom, Grove & Dimmock, 2012). Adaptive perfectionism had a positive influence on relative autonomy and self-presentation processes, whereas maladaptive perfectionism exerted a direct negative effect on relative autonomy and a direct positive effect on self-presentation. The authors of this study proposed that motivational factors may provide insight into how perfectionism influences patterns of aerobic exercise behaviour.

Perfectionism has also been associated with burnout in elite athletes. Studies have shown that burnout is positively related to maladaptive perfectionism and negatively related to adaptive perfectionism (Lemyre et al., 2003; Appleton et al., 2009). The signs and symptoms of burnout are similar to those of the overtraining syndrome and include fatigue, exhaustion, mood disturbances, and performance impairment (Lemyre, Roberts & Stray-Gundersen, 2007). Unlike the overtraining syndrome, however, burnout is also marked by decreased motivation and sport devaluation (Lemyre et al., 2007). Potential causes of burnout include the physical demands of heavy training, insufficient recovery between workouts, and/or psychosocial stress (Raedeke, 2014).

The trait of perfectionism has been cited as a possible determinant of exercise addiction (Hagan & Hausenblas, 2003) and/or of heavy training loads (Williams & Andersen, 2007). The link between neuroticism and exercise addiction (Hausenblas & Giacobbi, 2004) supports the plausibility of this hypothesis, given the labelling of perfectionistic concerns as, ‘neurotic perfectionism’ (Frost et al., 1990). There is also evidence that perfectionism may predict potentially dysfunctional behaviours in the general population. For instance, perfectionism has been positively associated with measures of compulsivity (Frost et al., 1990) and with work addiction, or ‘workaholism’ (Bovornusvakool, Vodanovich, Ariyabuddhiphongs & Ngamake, 2012). Other investigators found that alcohol problems and the use of alcohol as a coping strategy were higher in maladaptive perfectionists in comparison with adaptive perfectionists and non-perfectionists (Rice & van Arsdale, 2010).

A growing body of research is consistent with the view that perfectionism is a risk factor for problem exercise behaviour. For example, several investigators have reported significant differences in perfectionism scores between addicted and non-addicted groups of college students and general exercisers (Gulker et al., 2001; Hagan & Hausenblas, 2003; Lichtenstein et al., 2014). In one of these studies, exercise addiction was also positively related to body dissatisfaction and a drive for thinness (Gulker et al., 2001). However, unidimensional measures of perfectionism were used in this research. This could potentially fail to capture the complexity of the relationship between these two constructs (Hill et al., 2015).

A few investigations have employed multidimensional instruments to assess perfectionism and exercise addiction in populations of students and general exercisers. The findings of this research are mostly consistent with the results of studies utilizing unidimensional measures of perfectionism. For example, Taranis and Meyer (2010) reported a positive association between dimensions of perfectionism and exercise addiction in young female university students. The findings of this study also indicated that self-criticism accounted for the observed relationship between adaptive perfectionism and exercise addiction. In other research, college students classified as at risk for exercise addiction had higher scores on four dimensions of Frost et al.'s (1990) Multidimensional Perfectionism Scale (MPS) in comparison with their low-risk counterparts (Downs et al., 2004). 'Addicted' exercisers in this study obtained higher scores on the Personal Standards, Concern over Mistakes, Doubts about Actions, and Parental Criticism subscales of the MPS. In research involving general exercisers, significant positive associations have been reported between exercise addiction and self-oriented perfectionism (Hill et al., 2015; Miller & Mesagno, 2014), socially-prescribed perfectionism (Miller & Mesagno, 2014), and perfectionistic trait presentation styles (perfectionistic self-promotion, non-display of imperfection, and non-disclosure of imperfection) (Hill et al., 2015).

A key limitation of exercise addiction studies involving college students is the probable low prevalence of the disorder in these groups (Hall et al., 2009). Exercise addiction may be more common in individuals whose identity is strongly connected to being physically active (Hall et al., 2009). Only a small number of investigations have examined how perfectionism is related to exercise addiction and related constructs in athletic sub-groups. One of these studies assessed the associations between perfectionism and running addiction in 307 British distance runners (Hall et al., 2009). Using structural equation modelling techniques and validated multidimensional measures of both constructs, researchers observed a significant, positive association between perfectionism and running addiction. Among the findings were that self-oriented perfectionism had a direct, positive effect on running addiction, while unconditional self-acceptance fully mediated the relationship between socially-prescribed perfectionism and running addiction.

The reported link between perfectionism and running addiction was consistent with the results of two earlier investigations involving runners in the United Kingdom (Hall et al., 2007a; 2007b). In Hall et al.'s (2007a) study, perfectionism was assessed using Frost et al.'s (1990) Multidimensional Perfectionism Scale, while a measure of running addiction that included emotional, cognitive, and behavioural components of running engagement was utilized. Correlational analyses revealed that running addiction was significantly associated with overall perfectionism and all five perfectionism scales: Personal Standards, Concern over Mistakes, Doubts about Actions, Parental Expectations, and Parental Criticism. However, multiple regression analyses showed that only Personal Standards and Concern over Mistakes contributed unique variance to the prediction of running addiction. In the second investigation, it was reported that a combination of self-oriented and socially-prescribed perfectionism and specific motivational processes accounted for 38% of the variance in exercise addiction scores (Hall et al., 2007b). The three studies cited above support the hypothesized link between perfectionism and running addiction. Although it has been posited that perfectionism may also influence the training levels of endurance athletes (Williams & Andersen, 2007), it seems that this hypothesis has not been tested.

Type A Behaviour Pattern: Correlates and Consequences

The Type A behaviour pattern was originally documented as an important risk factor for the development of coronary heart disease (Lee et al., 1996). It has been posited, however, that certain dimensions of the construct may predict positive behaviours and outcomes (Lee, Ashford & Jamieson, 1993). For instance, the achievement striving component of Type A has been related to enhanced performance and greater problem-focused coping (Lee et al., 1993). Nonetheless, this personality type is generally considered to be maladaptive (Ward & Eisler, 1987).

Ironically, despite being described as "a coronary-prone behaviour pattern" (Burnman et al., 1975, p. 76), there is a lack of evidence that Type A is a risk factor for coronary heart disease (Petticrew, Lee & McKee, 2012). Nevertheless, in support of its hypothesized deleterious effects, the Type A construct has been linked to various adverse cognitions, emotions, and behaviours. Martin et al. (1989) reported that individuals with high scores on a Type A inventory experienced greater depression compared with low scorers. Among females in this study, Type A behaviour was associated with lower self-esteem, higher perceived stress, and emotion-focused coping. Specific dimensions of the Type A construct have also been positively related to anxiety and inversely related to problem-focused coping (Lee et al., 1993). A prospective study adopting a 28-year follow-up provided convincing evidence for the role of Type A behaviour in predicting negative affect (Sogaard, Dalgard, Holme, Roysamb & Haheim, 2008). The authors found that Type A behaviour was significantly associated, both cross-sectionally and prospectively, with psychological distress in a large cohort of men. Consequently, it seems plausible that Type A runners may use exercise as a coping strategy, which may, over time, become maladaptive, increasing the risk for exercise addiction.

The Type A behaviour pattern has also been examined in the context of physical activity and exercise (Lidor, 2014; Rhodes, 2014). In several studies, certain components of the construct have been related to various potentially adaptive dimensions of exercise behaviour. For example, in a large-scale prospective study, researchers found that youths' scores on the leadership dimension of Type A behaviour predicted higher physical activity levels 21 years later (Yang et al., 2012). The leadership component of Type A mainly reflected perceived status as a leader across situations and the general desire to win. Other dimensions of the Type A construct, such as a hard-driving approach, eagerness–energy, and aggression, were only marginally associated with physical activity in this study. In other research, Type A variables explained a significant percentage of the variance in exercise maintenance scores in a voluntary five-month physical fitness programme comprising walking, jogging, and aerobic dancing (Goffaux & And, 1987). A further study showed that Type A college students devoted more time to exercise and had a more positive attitude towards competitive and elite sport participation relative to their non-Type A peers (Hassmen & Koivula, 1998). Interestingly, a bidirectional relationship has been posited between Type A behaviour and physical activity (Lidor, 2014). However, there is currently limited evidence that aerobic training can modify specific components of the construct (Lidor, 2014).

Negative outcomes associated with the Type A behaviour pattern in sport and exercise settings have also been documented. For instance, several researchers have found that the Type A construct may predict increased injury incidence in distance runners (Diekhoff, 1984; Ekenman et al., 2001; Fields et al., 1990). A 12-month longitudinal study involving 40 recreational runners noted that high scorers on the Type A Self-Rating Inventory (TASRI) were significantly more likely to report injury occurrences compared with low scorers (Fields et al., 1990). It was observed that 57% of runners with scores above 120 on the TASRI experienced injuries compared with 34.6% of runners scoring below this threshold. Injury and training data were self-recorded in monthly training logs, which were reviewed on a monthly basis. The results of this study were consistent with an earlier investigation involving 68 distance runners (Diekhoff, 1984). Further to this research, Ekenman et al. (2001) reported that runners sustaining clinically-verified stress fractures of the tibia (n = 17) had significantly higher scores on various Type A inventories relative to matched controls with no history of stress fractures (*n* = 17). It was speculated that runners with stress fractures, particularly females, may feel the constant pressure to perform above normal levels, thus increasing injury risk. A notable limitation of these studies, however, is the small sample sizes.

It has been proposed that potentially harmful training habits may mediate the Type A–injury relationship (Ekenman et al., 2001; Fields et al., 1990). In general, Type A runners may tend to overexert themselves, to persist with training despite injuries or illness, or to resume training too quickly after injury (Ekenman et al., 2001; Fields et al., 1990). These behaviours may, in turn, increase injury risk or exacerbate an existing injury.

The results of experimental research support the plausibility of these ideas. For example, Burnam et al. (1975) demonstrated that Type A individuals applied near maximum effort when working on a task, regardless of the demands of the task. Another intervention study found that high Type A scorers exerted significantly more effort during a competitive versus noncompetitive timed cycling trial (Masters, Lacaille & Shearer, 2003). This strong desire to outperform others may lead to intense striving in competitive sporting contexts. Ward and Eisler (1987) found that Type A individuals were prone to set unrealistically high goals and to evaluate their performance against extreme standards. The failure to attain success was associated with increased psychological distress. Similarly, Martin et al. (1989) observed that Type A behaviour was associated with a set of dysfunctional attitudes about the importance of achieving overly challenging goals for self-worth purposes. It is conceivable that these Type A characteristics could foster maladaptive achievement striving and the adoption of unhealthy exercise patterns.

Despite the assertion that the Type A construct may influence running behaviour, there appears to be little direct support for this hypothesis. In their study of the Type A–injury relationship, Fields et al., (1990) failed to detect a significant correlation between Type A behaviour and training volume or between training variables and self-reported injuries. The authors remarked that other training factors, such as workout intensity and frequency, may also need to be considered in such research. As only 40 runners were included in this study, larger investigations are required in order to explore this relationship further.

Some investigators have reported that Type A behaviour may predict increased neuroticism, which has, in turn, exhibited a positive relationship with exercise addiction (Adams & Kirkby, 2001). This provides indirect support for a possible association between Type A behaviour and potentially harmful exercise. In other research, several physiotherapists described patients who they perceived as being addicted to exercise using the terms, 'Type A', 'overachieving', and 'obsessive' (Adams & Kirkby, 1997). However, the lack of valid and reliable measuring instruments and reliance on respondents' personal interpretations is a major limitation of this study.

Relationship between Perfectionism and Type A Behaviour

Several researchers have posited that, due to conceptual similarities between the two constructs, perfectionism and Type A behaviour are likely to be positively related (Flett et al., 1994; Flett, Panico & Hewitt, 2011). Common dominant theoretical themes include the importance of high personal standards of achievement for self-validation and self-worth purposes. Studies have also shown that the parents of Type A individuals are often overly-demanding and castigatory (Flett et al., 1994). Similarly, theorists believe that perfectionism stems from perceptions of high parental expectations and conditional acceptance (Frost et al., 1990). Research involving student samples has supported the hypothesis that perfectionism and Type A behaviour are related (Flett et al., 1994; Flett et al., 2011). It seems, though, that the relationship between Type A and perfectionism in athletic populations has not yet been examined.

Achievement Goals and Exercise Behaviour: The Research

Achievement goal theory predicts that achievement goals influence cognitive, affective, and behavioural processes and outcomes in achievement contexts (Conroy & Hyde, 2014). Theorists have postulated that the different goal orientations may have dissimilar and sometimes opposing correlates and consequences. It has been maintained that task goal orientation is primarily adaptive, whereas ego goal orientation is often maladaptive (Elliott & Dweck, 1988; Roberts et al., 2007; Tenenbaum et al., 2005). A goal orientation represent the tendency to be task and/or ego involved in achievement contexts (Roberts et al., 2007; Roberts et al., 1998).

Research examining the correlates and consequences of achievement goal orientations in sport and exercise domains has largely supported these hypotheses (Biddle et al., 2003; Conroy & Hyde, 2014; Roberts et al., 1998). For example, studies have shown that task goals are related to positive cognitions and emotions, like interest, enjoyment, achievement satisfaction, and commitment. Conversely, ego goals seem to predict more adverse outcomes, such as greater anxiety, worry, competitiveness, and public self-consciousness (Conroy & Hyde, 2014).

In a systematic review of the literature, it was reported that task goal orientation was related to beliefs that effort causes success and that the purpose of sport is to develop mastery, self-esteem, and health/fitness (Biddle et al., 2003). Task goals were also associated with adaptive achievement strategies, such as practice mastery and persistence, and with higher positive affect and lower negative affect. Participation motives of task-involved individuals included skill development and team membership. Task orientation also predicted motivation-related behaviours, such as effort, persistence, and the selection of moderately challenging goals. However, these effect sizes were generally small.

In contrast, ego goal orientation was associated with beliefs that ability leads to success and that the purpose of sport/physical education is to achieve enhanced social status (Biddle et al., 2003). It was found that participation motives of ego involved individuals were mainly linked to status/recognition and competition. Ego goals also predicted unsportspersonlike attitudes and aggressive behaviours. Contrary to expectations, however, ego orientation was unrelated to positive or negative affect, and its link to achievement strategies appeared to be inconclusive. The majority of investigations reviewed revealed no association between ego goals and motivation-related behaviours. Both task and ego goal orientations were positively related to perceived competence.

Based on the literature review conducted by Biddle et al. (2003), there is stronger evidence that task goals are adaptive and less support for the belief that ego goals are maladaptive in physical activity settings. Task orientation consistently predicted more positive emotions, cognitions, motives, and achievement strategies. In common with task goals, ego goals were related to higher perceived competence, a desirable outcome. The association between ego orientation and affective or behavioural factors was either nonsignificant or uncertain. For example, contrary to the tenets of achievement goal theory, ego goals were unrelated to motivation-related behaviours, such as effort, task choice, and/or persistence, in the majority of studies examined.

This latter finding was corroborated in a subsequent intervention study (Tenenbaum et al., 2005). Researchers reported that ego goal orientation was unrelated to physical effort perseverance in a physically demanding aerobic exercise (i.e., running) condition. Thus, the hypothesis that ego-goal endorsement would predict less effort in an ego-threatening context was not supported. The investigators also expected that task goal endorsement would be related to greater effort perseverance when performing an arduous task. However, this hypothesis was also unsupported. It was found instead that task-specific psychological variables, such as perceived competence, confidence, and readiness to invest effort, accounted for most of the variance in perseverance.

Relationships have been observed between achievement goal orientations and different forms of motivation (Grant & Dweck, 2003; Ozkan, Cetinkalp & Bas, 2012). For example, task goals have been associated with higher intrinsic motivation (Grant & Dweck, 2003), while ego goals have been linked to less self-determined forms of motivation (Ozkan et al., 2012). In a study involving young adult distance runners, ego orientation was inversely associated with amotivation, but neither goal orientation was related to intrinsic or extrinsic motivation (Ozkan et al., 2012).

These motivation constructs can be viewed in the context of self-determination theory and its sub-theory, organismic integration theory (Ryan & Deci, 2000). Extrinsic motivation refers to performing an activity for reasons that are external to the activity. When intrinsically-motivated, individuals engage in behaviours for reasons that are integral to the activity, such as interest and enjoyment. Each of these dimensions, in turn, is associated with varying degrees of perceived autonomy or self-regulation (Ryan & Deci, 2000). According to self-determination theory, amotivation refers to “the state of lacking the intention to act” (Ryan & Deci, 2000, p. 72). This may be due to not valuing an activity, low perceived competence, or not expecting an activity to produce a desired outcome (Ryan & Deci, 2000). Amotivation is located on the opposite end of the spectrum to intrinsic motivation, which represents the highest level of self-determination (Kirk, Cooke, Flintoff & McKenna, 2008).

Research adopting a hierarchical approach to the achievement goal construct has provided further evidence of associations between achievement goals and cognitive, affective, and/or behavioural processes and outcomes in sport and exercise. In one study, fear of failure was positively linked to mastery avoidance, performance avoidance, and performance approach goals (Conroy, Elliot & Hofer, 2003). In general, there is evidence that mastery approach goals predict desirable outcomes, such as perceived competence, greater enjoyment, increased positive affect, lower self-handicapping, and increased fitness and physical activity participation. Performance approach goals have tended to exhibit a mixed set of consequences (Conroy & Hyde, 2014; Roberts et al., 2007). These goals have been positively related to negative outcomes, such as self-handicapping, yet have also been associated with increased physical activity, satisfaction, perceived competence, enjoyment, interest, and performance (Conroy & Hyde, 2014; Roberts et al., 2007). Performance approach and mastery approach goals are conceptually equivalent to ego goals and task goals, respectively, in the dichotomous model of achievement goals (Roberts et al., 2007).

Some limitations of research investigating the correlates and/or outcomes of achievement goal orientations have been noted. Biddle et al. (2003) have stated that the majority of studies in this field have involved older children and adolescents. Adult populations have been included in only about 25% of investigations. Also, almost all studies have employed self-report measures and cross-sectional designs, which prohibit causal interpretations. Other researchers have maintained that the influence of goal orientations on motivation and performance mainly depends on how these constructs have been operationalized (Grant & Dweck, 2003).

Although it is probable that achievement goal orientations may predict quantitative and/or qualitative dimensions of exercise behaviour (Hall et al., 2007a), little is known about this topic. However, associations between other motivation constructs and exercise addiction in endurance athletes have been reported. For example, Hamer et al. (2002) noted a link between participation motives and exercise addiction in runners, swimmers, triathletes, and duathletes. In this study, introjected regulation and identified regulation, which are both types of extrinsic motivation, were significant predictors of exercise addiction. Introjected regulation was the strongest predictor variable. Regulatory processes characteristic of introjected regulation include self-control, ego-involvement, and internal rewards and punishment (Ryan & Deci, 2000). Therefore, exercise addiction may be most related to motives to avoid guilt or anxiety, and/or to experience feelings such as pride (Hamer et al., 2002). Personal importance and conscious valuing of an activity regulate identified regulation. Integrated regulation, a more autonomous form of extrinsic motivation, and intrinsic motivation, the most self-determined type of motivation, were not significant predictors of exercise addiction. Other researchers have hypothesized that extrinsic motivation is related to lower levels of adherence in competitive athletes and general exercisers (Frederick-Recascino & Schuster-Smith, 2003).

Research investigating the role of achievement goal orientations in exercise addiction and related constructs appears to be extremely limited. However, achievement goal orientations have been associated with burnout in athletes. In a study involving elite competitors, burnout risk was positively associated with ego goal orientation and negatively related to task goal orientation (Lemyre et al., 2003). Other researchers reported that a perceived ego-involving climate and mastery avoidance goals predicted a higher risk of burnout symptoms in young elite athletes (Isoard-Gautheur et al., 2013). A perceived task-involving climate and mastery approach goals were related to a lower risk of burnout in these individuals.

Further to this research, a cross-sectional study found that a combination of goal orientations, perceived ability, concern about mistakes, and high personal standards explained 31% of the variance in exercise addiction in distance runners (Hall et al., 2007a). Both task and ego goal orientation positively predicted exercise addiction, although the link between task goals and compulsive exercise was unexpected. Task goals may, however, energize approach or avoidance behaviour. This led the authors to speculate that striving to avoid personal incompetence, which is also a feature of neurotic perfectionism, may promote maladaptive, rather than adaptive exercise behaviour. A further unexpected finding was the positive association between high perceived ability and exercise addiction. It was conjectured that athletes with high perceived ability may be inclined to persevere when facing setbacks. However, if goals are not achieved, this investment of effort may become incapacitating, and exercise may be perceived as all-consuming. The authors also stressed the importance of viewing the effects of task goals and perceived ability in conjunction with the influence of other motivational variables. In combination, these factors may foster a focus on self-validation and failure avoidance, increasing the risk for pathological forms of exercise behaviour (Hall et al., 2007a).

Finally, positive correlations have been documented between task and ego goal orientation in several studies (Hall et al., 2007a; Ozkan et al., 2012), suggesting that these variables are independent, yet related constructs.

Exercise Behaviour, Injuries, and URTIs: The Research

There is convincing evidence that regular physical activity is associated with improved physical health and psychological functioning (Dubbert, 2002; Khatri & Blumenthal, 2007). Habitual exercise has been related to a decreased risk of developing hypertension, osteoporosis, diabetes mellitus, and colon cancer (Dubbert, 2002). In a classic longitudinal study involving almost 17 000 Harvard alumni, regular physical activity, such as walking, stair climbing, and sports play, predicted lower total mortality – particularly with respect to death due to cardiovascular and respiratory diseases (Paffenberger et al., 1986). Further benefits of exercise include increased fatigue resistance, improved muscular strength and endurance, enhanced flexibility, and better weight management (Landolfi, 2012). In distance runners, consistent aerobic training has been linked to a lower incidence of a number of serious health disorders, such as cancers, coronary artery disease, seizure disorders, diabetes, and human immunodeficiency virus (HIV) infection (Hoffman & Krishnan, 2014).

Physical activity and exercise may also provide a number of psychological benefits. Cross-sectional studies have reported higher self-esteem, self-confidence, and emotional well-being; and lower depression and anxiety in regular exercisers relative to sedentary individuals (Khatri & Blumenthal, 2007). Longitudinal research has shown that exercise may effectively reduce stress, anxiety, and depression, while intervention studies suggest that regular exercise may improve self-concept, self-esteem, and self-efficacy (Khatri & Blumenthal, 2007). Also, a group of researchers reported self-perceived superior quality of life in older athletic competitors compared with their sedentary peers (Shephard et al., 1995).

Despite the considerable benefits provided by regular exercise, distance running may sometimes have negative physical health effects. For example, researchers have observed a higher incidence of allergy and/or asthma symptoms in marathon runners compared with the general population (Hoffman & Krishnan, 2014; Robson-Ansley et al., 2012). Many runners will also experience a running-related injury, and heavy endurance exercise may increase susceptibility to upper respiratory tract infections. The main purpose of this segment is to review studies examining the effects of qualitative and quantitative dimensions of exercise behaviour on overuse injury and URTI risk, particularly in distance runners. Due to its potential relevance in the current context, research exploring the link between psychosocial stress and athletic injuries/URTIs will also be considered.

Psychosocial Stress, Athletic Injuries, and URTIs

A stressor has been defined as any physical or mental demand to which the individual must adjust (Collins et al., 2003; Selye, 1975). Physical stressors challenge the normal capacity of the body, while mental stressors test psychological adaptability (Collins et al., 2003). Competitive athletes are often exposed to both forms of stressors as intense training and competition is both physically and psychologically demanding (Adams & Kirkby, 2001; Hancock & Hancock, 2014). Psychosocial stress may, in turn, exacerbate the effects of heavy exercise on training maladaptations, URTIs, and injuries (Appaneal & Perna, 2014). An addiction to exercise could also increase exposure to stressors like major life events (Berczik et al., 2012). This suggests that research examining the effects of psychosocial stress on injury and URTI incidence warrants evaluation in the present setting. Regardless of their source, stressors elicit marked physiological changes that can impair both immune function and skeletal muscle repair ability, thus potentially increasing illness and injury risk (Appaneal & Perna, 2014).

Stress and Athletic Injuries

A number of researchers have documented associations between psychosocial stress and sport injury incidence (Cramer & Perna, 2000; Junge, 2000). For example, Galambos, Terry, Moyle and Locke (2005) found that stress scores significantly predicted injury characteristics in a fairly large and diverse sample of high-level athletes. This group included runners, triathletes, and swimmers. A positive relationship between stress and injury problems was also observed in a small-scale, prospective study involving elite soccer players (Ivarsson & Johnson, 2010) and in two prospective studies involving elite athletes from various sports (May, Veach, Reed & Griffey, 1985a; May, Veach, Southard & Herring, 1985b). In a comprehensive review of the literature, Junge (2000) stated that life events appear to increase injury incidence in athletes, with social support buffering this relationship.

Stress and Immune Function

In support of the hypothesized adverse effects of psychosocial stress on the immune system, several investigators have reported that stressful life events are related to impaired immunity in the general population (Connor, 2008; Kiecolt-Glaser, McGuire, Robles & Glaser, 2002; Bartrop, Luckhurst, Lazarus, Kiloh & Penny, 1994; Drummond & Hewson-Bower, 1997; Irwin, Daniels, Bloom, Smith & Weiner, 1987; Jemmott & Magloire, 1988). Cumulative life event stress has been associated with lower natural killer cell cytotoxic activity in women (Irwin et al., 1987) and reduced salivary concentrations of secretory immunoglobulin A (IgA) in children (Drummond & Hewson-Bower, 1997). Commonplace, relatively short-term stressors, such as examinations, have also been linked to lower salivary IgA concentrations (Jemmott & Magloire, 1988) and other adverse immune changes (Kiecolt-Glaser et al., 2002). Natural killer cells and secretory IgA are part of the innate or 'naturally occurring' immune system (Brenner, Shek & Shephard, 1994), and they play a key role in defending a host against viral infection (Kugler, 1994; O'Toole, 1998). Immune dysregulation has also been observed in individuals experiencing a chronic stressor, such as unemployment (Kiecolt-Glaser et al., 2002), or a major life event, like bereavement (Bartrop et al., 1994).

Stress and URTIs

There is fairly strong evidence that stress may be related to increased susceptibility to upper respiratory tract infections in the general population. Prospective epidemiological surveys have found a positive relationship between stressful life events and clinically-verified URTI incidence in children (Cobb & Steptoe, 1998; Drummond & Hewson-Bower, 1997) and adults (Cobb & Steptoe, 1996). Several intervention studies have also convincingly demonstrated that psychosocial stress may increase URTI susceptibility. For instance, in a well-controlled viral-challenge study involving 394 healthy volunteers, higher self-reported psychological stress was associated with increased infectious incidence following experimental exposure to a cold virus (Cohen, Tyrrell & Smith, 1991). Three measures of psychological stress were used in this study. These were the number of recent major life events rated as stressful, perceptions of current demands, and current negative affect. Each stress measure exerted an independent effect on URTI susceptibility. Current perceived stress and negative affect were also positively related to biological infection, while recent stressful life events were correlated with the development of clinical symptoms. It was noted that infection could occur in the absence of symptoms. In two other similar experiments, it was found that psychosocial stress predicted the severity of an infectious episode (Totman, Kiff, Reed & Craig, 1980; Cohen, Doyle & Skoner, 1999). Symptom severity scores were based on the number and intensity of symptoms experienced, as well as on objective criteria like levels of virus shedding and mucus production.

Stress and URTIs: athlete studies

Survey data from research conducted among elite and recreational athletes suggest that stress may be related to URTI risk in athletic populations. Positive associations between major life changes and respiratory disorders have been observed in elite athletes from various sporting codes (May et al., 1985a; 1985b). A positive correlation between life event stress and self-reported cold symptoms was also detected in a cross-sectional study involving South African distance runners of diverse ability, running experience, and training habits (Struwig et al., 2006). In other research, differences in levels of perceived stress were related to self-reported URTI incidence in a large sample of marathon runners (Nieman et al., 1990b). Specifically, 36% of runners assigned to a low-stress group reported recent URTI occurrences compared with 45.2% of those allocated to a high-stress group. Although this body of research is generally consistent with the findings of high quality studies in the general population (e.g., Cohen et al., 1991), several methodological limitations should be noted. These include the use of retrospective designs, self-report methods of data collection, and the lack of clinical verification of self-reported symptoms.

Finally, psychosocial stress has also been implicated in the development of the overtraining syndrome (Meehan et al., 2002). Athletes diagnosed as being chronically overtrained reported increased psychosocial stress in the six-month period prior to the occurrence of symptoms. It was found that training factors were unrelated to the development of this condition.

Exercise and Overuse Injuries

A perusal of the athletic injury literature from the past few decades suggests that a fairly large number of studies have investigated exercise-related risk factors for running injuries. However, most of these enquiries have examined the influence of measurable exercise characteristics, such as weekly training volume, on injury incidence. Few studies have explored the impact of qualitative or psychological dimensions of potentially harmful exercise behaviour on injury risk.

Training Factors and Overuse Injuries

Although it has been posited that the physical stress of excessive exercise may increase the risk of musculoskeletal injuries (Appaneal & Perna, 2014), the results of several empirical investigations, as well as various systematic reviews of the literature, indicate that this research is generally inconclusive.

The majority of studies examining the impact of training behaviours on injury incidence have assessed the effects of training volume on the outcome variable. Training volume refers to the average kilometres/miles run over a specific period (Nielsen et al., 2012). Based on the results of this research, some reviewers have concluded that higher weekly training volume may be a significant risk factor for the development of running injuries (Ryan et al., 2006; van Gent et al., 2007). However, it has been noted that this relationship has been observed mainly in male runners (Nielsen et al., 2012; van Gent et al., 2007). For example, a prospective cohort study found that a training distance of less than 40 kilometres per week was a protective factor for calf injuries in a cohort of male marathon runners (van Middelkoop et al., 2008). Running volume, though, did not predict overall injury incidence in this study.

A few researchers have observed positive associations between training volume and running injury risk in both male and female runners (Diekhoff, 1984; Layman & Morris, 1991). In one of these studies, 70.9% of athletes training more than 48 kilometres per week sustained an injury during the previous 12 months. Conversely, only 51% of runners covering less than 48 kilometres per week had been injured (Layman & Morris, 1991). However, the fairly lengthy recall period in this investigation could have influenced the accuracy of self-reported training and injury data. Aside from research in adult populations, higher training volumes have been associated with increased injury incidence among youth track and field athletes (Huxley, O'Connor & Healey, 2014).

The use of self-report methodologies in the above studies is likely to be a limitation of this research. Other investigators utilized MRI (mechanical resonance imaging) techniques to examine the relationship between training levels and chronic knee lesions in 26 male and female distance runners (Schueller-Weidekamm et al., 2006). It was found that runners with a higher training status had significantly elevated scores for MRI-assessed chronic knee lesions relative to runners with a lower training status. Despite the small sample size, a specific strength of this research was the use of an objective measure of running injuries.

Some investigators have queried whether it is the absolute amount of training or an increase in training volume that may be harmful (Ryan et al., 2006). Sudden versus more gradual increases in weekly training load could increase injury risk by allowing the body insufficient time for adaptation (Buist et al., 2008). A longitudinal study involving 12 male runners taking part in a multi-stage long-distance race over 20 days provided some support for this theory. In this research, large increases in daily running distance were associated with significantly elevated levels of serum creatine kinase, a marker of muscle tissue injury (Dressendorffer & Wade, 1983). Parallel to this, the athletes reported persistent mild-to-moderate levels of thigh muscle pain and stiffness. However, only one runner was unable to continue running because of injury. The authors noted that chronic running-related muscle injury may occur before performance changes are detected. A more recent, randomized, controlled trial found no significant differences in injury incidence between novice runners exposed to a graded, 13-week training programme and a control group participating in a standard eight-week programme (Buist et al., 2008). Although the hypothesis that increased adaptation time is related to lower injury risk was not supported, the investigators remarked that the training levels of the two groups may have been relatively similar (Buist et al., 2008). This could have accounted for the findings.

Although there is some evidence that higher training volumes may predict increased overuse injury incidence, several investigators have found no relationship between these variables (Ellapen et al., 2013; Fields et al., 1990; Hoffman & Krishnan, 2014; Rudy & Estok, 1989). For example, in a retrospective study involving a large cohort of marathon runners, total running volume in the preceding 12 months was unrelated to self-reported injury occurrence (Hoffman & Krishnan, 2014). In other research, injured versus non-injured South African club runners did not differ in terms of total distance run in the previous year (Ellapen et al., 2013). However, the long recall period in these investigations may have biased the reporting of both training and injury data.

In contrast to the previously cited studies, some researchers have found an inverse relationship between training volume and injury incidence (Fields et al., 1990; van Poppel et al., 2015). For example, a small-scale prospective study found that 80% of club runners averaging less than 32 kilometres per week had been injured versus 50% of those running more than 64 kilometres per week (Fields et al., 1990). In a systematic review of the literature, van Gent et al. (2007) concluded that there is strong evidence that higher weekly training volume is protective against knee injuries in runners, although the reason for this association is unclear.

Similarly, research examining the link between training intensity and running injury risk has yielded inconsistent findings (Nielsen et al., 2012). Training intensity typically describes the average pace of a training session (Nielsen et al., 2012). The results of some studies suggest that faster runners may be more susceptible to injuries than slower runners (Nielsen et al., 2012). However, this relationship is prone to weaken when adjustments are made for training volume (Nielsen et al., 2012).

In general, most investigations have found no significant association between training pace and injuries in adult runners (Nielsen et al., 2012; van Gent et al., 2007). For example, runners' training pace was not a significant risk factor for objectively-assessed chronic knee lesions (Schueller-Weidekamm et al., 2006). Subjective reporting of training pace may, however, be subject to recall bias, contributing towards the inconsistent results (Nielsen et al., 2012). Nonetheless, regular performance of interval training (alternating bursts of fast and slow running in a single session) was associated with reduced injury incidence in two prospective studies involving distance runners (van Middelkoop et al., 2008; van Poppel et al., 2015). Therefore, certain type of workouts may protect against injury development.

The relationship between overuse injuries and training frequency also appears to be relatively inconclusive (Nielsen et al., 2012; van Gent et al., 2007). Training frequency refers to the number of weekly workouts (Nielsen et al., 2012). There is some evidence that more frequent training sessions may increase injury risk (Layman & Morris, 1991; Nielsen et al., 2012; van Gent et al., 2007). For example, in one study, 67.6% of runners training more than five days a week in the year prior to assessment sustained an overuse injury during this period (Layman & Morris, 1991). In contrast, only 46.9% of those running less than five days a week had been injured. These results are in line with the belief that a lack of adequate rest and recovery between training sessions may increase susceptibility to overuse injuries (Buist et al., 2008; Johnston et al., 2003). However, other studies have reported higher injury incidence in runners training once a week relative to those training more often (Nielsen et al., 2012).

These findings suggest that, up to a point, more frequent exercise may help to build a training base that can withstand increased training volumes (Nielsen et al., 2012). On the basis of this research, Nielsen et al. (2012) proposed that a U-shaped association may exist between training frequency measures and overuse injury risk. Running two to five times a week may be optimal. However, when controlling for running volume, some studies have found no association between training frequency and injury risk (Nielsen et al., 2012).

Running to compete has also been cited as a risk factor for the development of overuse injuries (Buist et al., 2008; Ryan et al., 2006). In support of this, it has been shown that participating in more than six distance running events in a 12-month period may increase injury risk among male marathon runners (van Middelkoop et al., 2008). Other researchers noted that runners who had participated in three or more sub-marathon events in the preceding 12 months were more likely to report a prior injury relative to those running fewer races (Layman & Morris, 1991).

It has been stated that marathon runners may be more susceptible to overuse injuries than participants in shorter-distance events (Sanchez, Corwell & Berkoff, 2006; van Gent et al., 2007). Yet, in a large-scale prospective study, injury incidence did not differ in marathon relative to half-marathon runners during or after an event (van Poppel et al., 2015). Participants in races of 15 and 21.1 kilometres were, however, shown to experience more injuries compared to five and 10 kilometre runners both during the race and in the 12-month follow-up period (van Poppel, Scholten-Peeters, van Middelkoop & Verhagen, 2014). The authors of this study commented, however, that this may have been a chance finding.

The above research suggests that the association between training load and overuse injury risk may be complex. It has been argued that several training variables may interact with one another to influence running injury incidence (Nielsen et al., 2012). Many studies, however, have not considered the interrelationships among training volume, duration, intensity, or frequency (Nielsen et al., 2012). Therefore, there is limited knowledge of the independent and/or interaction effects of different training characteristics on injury incidence. Also, running injuries may be a result of either overuse or underconditioning (van Gent et al., 2007). Consequently, in some athletes, heavier training loads may enhance physical conditioning, which may protect against running injuries. Finally, it is generally difficult to draw any definitive conclusions from this body of research due to dissimilar definitions of running injuries employed across the various investigations.

Exercise Addiction and Overuse Injuries

A number of authors have postulated that exercise addiction can increase athletic injury risk (Adams & Kirkby, 1998; Adams & Kirkby, 2001; Berczik et al., 2012; de Coverley Veale, 1987; Downs & Hausenblas, 2014; Gapin et al., 2009; Hays, 2004; Iannos & Tiggemann, 1997; Landolfi, 2012; Lichtenstein et al., 2014). Although few researchers have tested this assertion, the available research has consistently demonstrated that exercise addiction may predict higher overuse injury incidence (Diekhoff, 1984; Ekenman et al., 2001; Layman & Morris, 1991; Lichtenstein et al., 2014; Rudy & Estok, 1989).

Congruent with the hypothesized adverse effects of exercise addiction, a case-control study found significant differences in self-reported injury occurrence between addicted and non-addicted general exercisers (Lichtenstein et al., 2014). The addiction group also reported significantly more general bodily pain than the controls. The well-validated Exercise Addiction Inventory was employed in this research. Individuals obtaining a score between 24 and 30 on this measure comprised the exercise addiction group (n = 41), while those scoring between six and 23 constituted the control group (n = 80).

In other research, running addiction was significantly related to self-reported injury history in male and female marathon runners (Rudy & Estok, 1989). However, running addiction scores only predicted hematuria (i.e., blood in the urine), which does not seem to qualify as an overuse injury, and torn ligaments. A unidimensional measure of exercise addiction, the Running Addiction Scale, was utilized in this study. A subsequent large-scale, cross-sectional investigation discovered a significant, positive association between running addiction and self-reported injuries over the previous year (Layman & Morris, 1991). Running addiction was operationalized as self-perceived addiction status and a tendency to experience unpleasant withdrawal symptoms when deprived of running. The results of this research supported the findings of an earlier investigation adopting a similar, unidimensional operational definition of running addiction (Diekhoff, 1984).

Among the limitations of the above-mentioned studies was the self-diagnosis of injury, which may have biased the results. In other research, it was found that runners sustaining clinically-verified stress fractures of the tibia had significantly higher exercise addiction scores relative to matched controls who had never experienced stress fractures (Ekenman et al., 2001). This was especially evident among the females in the sample. Stress fractures are injuries that usually develop slowly over time and can lead to lengthy layoffs from the sport (Ekenman et al., 2001). A specific strength of this study was the objective assessment of injury based on X-ray, bone scintigram, or magnetic resonance imaging techniques. Yet, due to the small sample size (N = 34), the results may need to be interpreted with caution (Ekenman et al., 2001). Also, it seems that the inventory utilized to measure problem exercise behaviour (i.e., The Commitment to Exercise Scale) was assessing the concept of commitment rather than addiction.

Exercise and URTIs

Studies examining the relationship between endurance exercise and upper respiratory tract infections have almost exclusively assessed the effects of observable or measurable dimensions of exercise, like training volume, on these health disorders. The role of exercise addiction in URTIs has received scant research attention. It has been postulated that the relationship between exercise load and susceptibility to URTI can be modelled in the form of a J-curve (Nieman, 2001). According to this hypothesis, regular, moderate exercise is protective against infections like the common cold and influenza, while acute or chronic heavy exercise may increase URTI risk.

A large number of studies have assessed the relationship between exercise load and susceptibility to URTIs in both athletes and general exercisers (Moreira et al., 2009). Immune function in these populations has also been measured in an effort to establish the role of exercise in resistance to upper respiratory infections.

Exercise Load and Immune Function

Moderate exercise and immune function

Intervention studies that have explored exercise-induced immune changes in previously sedentary individuals suggest that exercise of moderate intensity and duration may enhance certain immune parameters. For example, researchers found significant, yet modest increases in serum immunoglobulin levels in previously sedentary, mildly obese women after six weeks of aerobic training performed at an intensity of around 60% of heart rate reserve (Nehlsen-Cannarella et al., 1991). Investigators also observed significantly elevated salivary IgA concentrations in elderly subjects after a 12-month programme comprising endurance and resistance training (Akimoto et al., 2003). Several other studies have shown that regular, moderate-intensity exercise may enhance salivary IgA concentrations, which may, in turn, reduce URTI susceptibility (Gleeson, Pyne & Callister, 2003).

Researchers have also reported increased natural killer cell cytotoxic activity in previously sedentary women after six weeks of moderate-intensity aerobic training (Nieman et al., 1990a). However, this finding was not supported in another randomized, controlled trial (Nieman et al., 1993) or in several prospective studies (Nieman, 1997). It has, therefore, been speculated that endurance exercise may need to be vigorous in order to stimulate chronic enhancements in natural killer cell activity (Nieman, 1997).

Heavy exercise and immune function

Research assessing immune function in athletes during heavy training phases or following maximal or submaximal exercise suggests that chronic or acute exercise stress may alter various aspects of immunity (Gleeson, 2007; Gleeson et al., 2003; Lehmann, Wieland & Gastmann, 1997; Mackinnon, 2000; Nieman, 2001; Schumacher, Pottgiesser & Koenig, 2003). For example, it was found that neutrophil function in highly-trained athletes was suppressed during peak training compared with moderate training and sedentary controls (Hack, Strobel, Weiss & Weicker, 1994). Immune function was relatively unaltered during less intense training phases. Neutrophils are a key component of the innate immune system and protect against bacterial and viral pathogens (Hack et al., 1994; Nieman, 1997). It has been proposed that suppressed neutrophil function during heavy training may increase URTI susceptibility in endurance athletes (Nieman, 1997).

Reductions in other immune parameters, such as salivary IgA concentrations, have also been observed in athletes during periods of intensified training (Gleeson, 2007; Gleeson et al., 2003). Lower salivary IgA concentration has, in turn, been linked to increased URTI incidence (Gleeson, 2007; Gleeson et al., 2003). This suggests that certain exercise-induced immune modifications may be directly linked to URTI susceptibility.

Although heavy training may elicit various adverse immune changes, cross-sectional studies suggest that resting immune function in athletes during non-peak training periods is relatively similar to that of non-athletes (Gleeson, 2007). Resting immune function refers to the state of the immune system at least 24 hours after a training session (Gleeson, 2007). Some researchers have reported increased natural killer cell cytotoxic activity in marathon runners relative to sedentary controls (Nieman et al., 1995; Nieman et al., 1993). However, it has been claimed that exercise-induced changes in natural killer cell function are unlikely to be clinically significant (Gleeson, 2007).

There appears to be general consensus among researchers that several immune parameters are temporarily suppressed following acute heavy exertion (Gleeson, 2007; Mackinnon, 2000; Nieman, 1997; Nieman & Pedersen, 1999; Nieman, 2001; Schumacher et al., 2003). Intervention studies involving a wide range of athletes have shown that salivary concentrations of IgA are reduced for at least two hours after a bout of high-intensity exercise (Gleeson et al., 2003). Transient exercise-induced impairments in other immune components, such as neutrophil function and natural killer cell cytotoxic activity, have also been reported (Mackinnon, 2000; Nieman & Pedersen, 1999; Nieman, 1997; Schumacher et al., 2003). Conversely, some researchers have observed increased natural killer cell activity after maximal aerobic exercise (Tate, Schuler & Pruett, 1998). It has been suggested that these conflicting findings may be due to differences in the way natural killer cell activity has been measured across studies (Nehlsen-Cannarella, 1998).

Exercise-induced immune modifications may persist for up to 72 hours, creating an open window period during which URTI resistance is temporarily decreased (Nieman & Pedersen, 1999; Nieman, 2001; Schumacher et al., 2003). The duration of immunosuppression is dependent upon the intensity and duration of the exercise bout (Gleeson, 2007). Prolonged, continuous exercise lasting longer than 1.5 hours and performed at an intensity of 55-75% of maximum heart rate is associated with the most marked immune changes (Gleeson, 2007).

Repeated, high-intensity training sessions may lead to long-term suppression of immune function and increased susceptibility to URTIs (Gleeson, 2007; Gleeson et al., 2003). However, there is little direct evidence linking exercise-induced immune modifications to clinically-confirmed incidents of upper respiratory illness (Gleeson, 2007; Nieman, 2001; Schumacher et al., 2003).

Exercise Load and URTIs

Moderate exercise and URTIs

Evidence supporting the role of moderate exercise and physical activity in URTI risk is limited (Moreira et al., 2009). However, preliminary data indicate that regular, moderate exercise and/or higher levels of physical fitness may provide some protection against viral infections (Gleeson, 2007; Moreira et al., 2009; Nieman, 2001). For example, two randomized, controlled trials have described reduced URTI symptomatology in subgroups of elderly and mildly obese women relative to sedentary controls following participation in 12–15 week moderate-intensity exercise programmes (Nieman et al., 1990a; Nieman et al., 1993). Subjects in these trials walked briskly for 30–45 minutes a day for five days a week at an intensity of 60% of maximum heart rate. Limitations of these studies included the homogeneity and small size of the research samples, which suggests that these results may not be generalizable to other members of the general population.

Research conducted among athletes suggests that routine vigorous yet non-excessive aerobic training may reduce URTI susceptibility compared with less intense exercise or inactivity. For example, 76% of 750 older endurance competitors perceived themselves as being less susceptible to viral infections compared to their sedentary counterparts (Shephard et al., 1995). Another study noted that highly-conditioned elderly women active in endurance competitions experienced significantly fewer respiratory infections relative to walking and calisthenic subgroups taking part in a controlled trial (Nieman et al., 1993). Various descriptive surveys have found that many non-elite marathon runners have experienced a reduced number of infectious episodes since taking up the sport (Nieman, 1997). Also, in recreational runners, higher versus lower weekly training volumes were related to fewer URTI episodes (Nieman, Johanssen & Lee, 1989). The authors of this study concluded that a more serious commitment to regular exercise among ‘fitness runners’ may be protective against infectious illness. In a 12-month longitudinal investigation, the annual URTI incidence in a large cohort of runners was almost half the rate recorded in previous general population research (Heath et al., 1991). However, since different data collection methods were used in these studies direct comparisons may not be entirely valid (Heath et al., 1991).

Heavy exercise and URTIs

The bulk of research exploring relationships between heavy exercise and infectious illness risk has examined the link between self-reported URTI symptomatology and training volume and/or marathon participation in competitive runners. Other training characteristics, such as workout intensity, frequency, or duration, have also occasionally been measured in these studies. A number of these investigations have reported a connection between chronic and/or acute heavy exercise and increased susceptibility to URTIs (Heath et al., 1991; Linde, 1987; Nieman et al., 1990b; Peters & Bateman, 1983; Peters et al., 1993; Robson-Ansley et al., 2012). However, some researchers have found either no relationship between measures of exercise/running load and infectious symptoms (Ekblom et al., 2006; Fricker et al., 2005; Struwig et al., 2006) or an inverse association between these variables (Martensson et al., 2014; Nieman, 1997; Peters et al., 1996).

In support of the potential adverse effects of chronic heavy exercise, several researchers have observed an association between high training volumes and increased URTI incidence. For example, running more than 97 kilometres per week in preparation for a marathon was identified as a significant risk factor for post-race URTIs compared with running 32 kilometres per week (Nieman et al., 1990b). Training intensity was unrelated to post-marathon URTIs. Additionally, a 12-month longitudinal study showed that an annual training volume exceeding 778 kilometres significantly increased URTI risk in distance runners (Heath et al., 1991). An annual training volume of between 1 386 and 2 221 kilometres was associated with the highest risk of infection. Conversely, neither weekly training volume nor frequency predicted URTI occurrences in this study. Linde (1987) observed a significantly higher annual incidence of upper respiratory illness in elite athletes compared with non-athletic matched controls. The duration of infectious episodes was also longer in the athletes, and significantly fewer athletes had remained infection-free during this period. Other researchers cited endurance sport participation and weekly training duration as significant predictors of respiratory illness in a heterogeneous population of athletes (Konig et al., 2002).

Various prospective studies conducted in South Africa have also reported positive associations between training volume and URTI symptoms. It was found that runners training more than 65 kilometres per week prior to the 56-kilometre Two Oceans Marathon experienced significantly more infectious symptoms during the two-week post-race period relative to those training less than 65 kilometres per week (Peters & Bateman, 1983). In another study, runners with a high training status, which was a function of training distance (volume) and intensity (running speed), reported a higher incidence of post-race URTI symptoms in comparison with a low-training-status group (Peters et al., 1993).

Several case-control studies suggest that running a marathon-type event may transiently increase URTI risk. Several investigators in South Africa and abroad have reported significantly higher post-race URTI incidence in marathon and ultramarathon participants relative to nonparticipating and/or sedentary controls (Nieman et al., 1990b; Peters & Bateman, 1983; Peters et al., 1993; Robson-Ansley et al., 2012). In one study, symptoms were mainly observed in faster runners, and there was no difference between URTI incidence in slower runners and control subjects (Peters & Bateman, 1983). However, certain limitations of this research should be noted. For instance, the response rate in Nieman et al.'s (1990b) study was low and may have been biased by runners who had experienced infections (Brenner et al., 1994; Moreira et al., 2009). Thus, the actual incidence of infection across all marathon finishers may have been lower than reported (Moreira et al., 2009). In Robson-Ansley et al.'s (2012) investigation, self-reported URTI symptoms were also positively related to the presence of allergy in the runners. This led the authors to postulate that immune-mediated inflammation and/or allergic disease, rather than infection, may explain most self-reported post-marathon URTIs.

A few studies, however, have failed to detect a significant relationship between chronic or acute heavy exercise and URTI incidence. In a large cohort of marathon runners, pre-marathon training load was unrelated to pre- or post-race self-defined infectious episodes (Ekblom et al., 2006). The finding of a positive correlation between pre- and post-race infections in this study implied that incomplete recovery from earlier infectious episodes may increase post-race URTI risk (Ekblom et al., 2006). A four-month prospective cohort study demonstrated that weekly training volume, intensity, and load (Volume × Intensity) were not related to URTI incidence in highly-trained male distance runners (Fricker et al., 2005). Although symptoms of respiratory illness were clinically verified at regular intervals, the research sample comprised only 20 athletes. These findings were consistent with the results of a retrospective study involving 124 South African distance runners that utilized a self-report methodology (Struwig et al., 2006). Measures of competition frequency and training duration, frequency, and workload (Duration × Intensity) were unrelated to URTI symptomatology in this investigation. Heath et al. (1991) also failed to detect an association between race participation and infection risk. Further, events of five kilometres, 10 kilometres, and 21.1 kilometres were unrelated to post-race URTI symptoms in recreational runners (Nieman et al., 1989). Thus, it has been proposed that post-race URTI risk may be increased only following marathon and ultramarathon events (Nieman, 1994).

Inverse associations between exercise load and susceptibility to URTIs have also been observed. In a South African study, ultramarathon runners with the lowest pre-race training status reported the highest incidence of URTI symptoms following the Comrades Marathon (Peters et al., 1996). More recently, data from training logs kept over several years indicated that training volumes were negatively related to the number of training days lost due to illness in a small sample of elite endurance athletes (Martensson et al., 2014). However, it is plausible that a higher number of training days off due to illness was responsible for reported lower training volumes in this study.

The inconsistent findings concerning the relationship between exercise load and URTI risk may be due to differences in research participants and/or methodologies employed (Moreira et al., 2009). For instance, it has been proposed that the J-shaped curve may tend to flatten in highly fit athletes (Moreira et al., 2009). In most studies reporting a positive relationship between training load and URTI, symptoms of infection were self-reported and were not clinically verified (e.g., Ekblom et al., 2006; Heath et al., 1991; Linde, 1987; Nieman et al., 1989; Nieman et al., 1990b; Peters & Bateman, 1983; Peters et al., 1993; Peters et al., 1996). Therefore, it is possible that self-reported URTI symptoms may have represented inflammatory responses rather than infectious illness (Gleeson, 2007). Symptoms may also have had an allergic origin or simply reflected a preoccupation with health (Peters & Bateman, 1983). Dissimilar operational definitions of URTI employed in the studies under review may also have contributed towards the conflicting results.

In conclusion, there is some evidence that chronic and acute heavy exercise may impair various immune parameters in athletic populations. However, due to the complexity of the immune system, it is unclear whether these changes affect immune function as a whole (Ekblom et al., 2006; Moreira et al., 2009). Still, it has been postulated that several small changes in immunity may together compromise resistance to minor ailments like URTIs (Gleeson, 2007). Although there is limited evidence to support this contention, the research shows that participation in marathons and ultramarathons may temporarily increase URTI susceptibility among distance runners. Also, it seems that high training volumes, especially in combination with marathon-type competitions, may be associated with an elevated URTI risk in this population.

Exercise Addiction and URTIs

In contrast to the abundance of studies examining quantitative dimensions of endurance exercise, research exploring the link between exercise addiction and URTIs appears to be non-existent. However, a number of investigators have asserted or implied that there is a positive relationship between quantitative and qualitative dimensions of unhealthy exercise engagement (Adams & Kirkby, 2001; Adams, Miller & Kraus, 2003; Adkins & Keel, 2005; de Coverley Veale, 1987; Downs & Hausenblas, 2014; Downs et al., 2004; Hausenblas & Downs, 2002b; Rudy & Estok, 1989). Therefore, the studies cited above may help shed light on the role of compulsive forms of exercise in URTI risk. Nevertheless, quantitatively excessive exercise does not necessarily imply addiction, while addicted exercisers may not always train to excess (Adkins & Keel, 2005). Thus, in order to obtain proper insight into the exercise addiction–URTI relationship, validated measures assessing behavioural, psychosocial, and physiological dimensions of the construct are needed.

A recent study examined differences in health-related quality of life between exercisers with and without symptoms of addiction (Lichtenstein et al., 2014). The instrument used to measure quality of life assessed components of both mental and physical health, which included bodily pain, physical functioning, and general health, among other variables. Differences in health-related quality of life between those at risk and not at risk for exercise addiction were not detected. However, the use of a generic health tool may have been inappropriate in this context (Lichtenstein et al., 2014).

Research supporting the hypothesized positive association between qualitative and quantitative dimensions of exercise behaviour is briefly reviewed below.

Relationship between Exercise Addiction and Exercise Load

It has been maintained that individuals addicted to exercise are likely to train excessively and without limitations (Adams & Kirkby, 2001). Accordingly, exercise addiction may predict higher training frequency and intensity, and increased training volume over time (de Coverley Veale, 1987; Downs & Hausenblas, 2014; Hausenblas & Downs, 2002a; Rudy & Estok, 1989).

In support of these assertions, it was found that physically-active individuals classified as at risk for exercise addiction exercised more strenuously than their low-risk counterparts (Downs et al., 2004; Hausenblas & Downs, 2002b). Other researchers reported that addicted exercisers trained for significantly more hours per week compared with non-addicted exercisers (Iannos & Tiggemann, 1997; Lichtenstein et al., 2014). The dimensions of training frequency and duration were also positively related to exercise addiction scores in a large pool of triathletes (Youngman & Burnett, 2008). Other investigators have documented an association between greater amounts of exercise and exercise addiction in regularly active women (Gapin et al., 2009). In another study, exercising five or more times per week predicted significantly higher exercise addiction scores relative to exercising twice or less per week (Terry et al., 2004). A positive association between training variables and exercise addiction was also demonstrated in a large-scale study involving runners (Layman & Morris, 1991). It was found that exercise-related withdrawal symptoms were more common in runners who had trained further and had run more races in the previous year. Also, the weekly frequency of training in runners with withdrawal symptoms had significantly exceeded the group mean score of five days. The authors of this research argued that withdrawal symptoms are an integral component of exercise addiction.

Summary and Conclusions

The main purpose of this chapter was to review previous empirical research relating to the present study. In keeping with this aim, studies investigating personality trait influences on exercise behaviour were examined, with an emphasis placed on perfectionism and Type A behaviour pattern. The impact of these personality dispositions on emotions, cognitions, behaviours, and outcomes in general was also considered. Research exploring the correlates and consequences of achievement goal orientations in the domain of sport and exercise was also assessed. Finally, studies examining the role of various dimensions of exercise behaviour on injury and URTI risk were reviewed. Investigations concerning the role of psychosocial stress in athletic injuries and URTIs formed part of this discussion.

On the basis of this literature survey, it can be tentatively concluded that overall perfectionism and specific dimensions of the construct may predict potentially harmful exercise patterns. Since research examining the relationship between Type A behaviour pattern and maladaptive exercise is extremely limited, the association between these variables is uncertain. There is some evidence that achievement goal orientations may predict exercise addiction in distance runners. It can also be deduced that high training volumes and the psychophysiological stress of marathon-type competitions may increase URTI susceptibility in distance runners. A small body of research suggests that exercise addiction is associated with a higher risk of overuse injuries in distance runners, although the role of training load in injury incidence is less clear.

In the following chapter, the research hypotheses, along with the design and methodological aspects of the study will be described and discussed.

CHAPTER 4

RESEARCH DESIGN AND METHODOLOGY

The purpose of the present study was to investigate the psychological antecedents of potentially harmful dimensions of exercise behaviour, and their effects, in turn, on common physical health problems in South African distance runners. More specifically, the main research objectives were to explore (1) the effects of perfectionism, Type A behaviour pattern, and achievement goal orientations on running addiction and training load and (2) the impact of running addiction and training load on self-reported running injuries and upper respiratory tract infections (URTIs). Further research aims were to examine the impact of running addiction on training load and to investigate certain interrelationships among perfectionism, Type A behaviour, and achievement goal orientations. In this chapter, the research hypotheses, along with the design and methodological aspects of the study, are presented and discussed.

The Research Hypotheses

In line with the study objectives and in accordance with relevant theory and research, a number of research hypotheses were formulated and tested. These suppositions, together with a brief rationale for each statement, are presented below.

Direct Effects

Hypothesis 1

Perfectionism has direct, positive effects on running addiction risk.

Hypothesis 2

Perfectionism has direct, positive effects on training load.

Rationale for Hypotheses 1 and 2

It has been posited that perfectionists' self-worth is contingent upon their level of achievement in relation to others (Ellis, 2002). It is conceivable that irrational cognitions such as this may promote maladaptive striving among committed runners, manifesting in potentially harmful training patterns. Perfectionistic self-presentation concerns may also motivate and encourage an unhealthy preoccupation with exercise due to impression-management needs (Flett & Hewitt, 2005). Further, some perfectionists may become dependent on running as a means of coping with perceived stress and negative affect. Finally, the empirical literature supports the hypothesis that perfectionism predicts problem exercise behaviour in distance runners (Hall et al., 2007a; 2007b; 2009).

Hypothesis 3

Type A behaviour has direct, positive effects on running addiction risk.

Hypothesis 4

Type A behaviour has direct, positive effects on training load.

Rationale for Hypotheses 3 and 4

The desire to promote and maintain a positive sense of self-worth via the attainment of unrealistically high performance standards (Martin et al., 1989) may foster excessive achievement striving among Type A runners. Consequently, these individuals may be inclined to adopt unhealthy or self-defeating training habits in order to achieve their goals. Also, the various dysfunctional cognitions and behaviours associated with the Type A construct may increase stress and negative effect (Martin et al., 1989; Smith & Anderson, 1986). Therefore, some Type A runners may use exercise as a maladaptive coping strategy, increasing the risk for dependence. In empirical research, Type A behaviour has been positively related to running injury risk (Diekhoff, 1984; Ekenman et al., 2001; Fields et al., 1990). It is plausible that dysfunctional training behaviours may account for this relationship (Ekenman et al., 2001; Fields et al., 1990).

Hypothesis 5

Task goal orientation has a direct, positive effect on training load.

Hypothesis 6

Ego goal orientation has a direct, positive effect on running addiction risk.

Hypothesis 7

Ego goal orientation has a direct, positive effect on training load.

Rationale for Hypotheses 5, 6, and 7

Achievement goal theory and a growing body of research suggest that a task goal orientation is primarily adaptive in achievement contexts, whereas an ego goal orientation is more likely to be maladaptive (Biddle et al., 2003; Conroy et al., 2003; Elliott & Dweck, 1988; Isoard-Gautheur et al., 2012; Lemyre et al., 2003; Roberts et al., 2007; Tenenbaum et al., 2005). It has been stated that task-involved runners should tend to exert effort and persist in the face of obstacles or setbacks as achievement is self-referenced and perceived as controllable (Hall et al., 2007a). Tasks goals should also promote flexible achievement striving in sport and exercise contexts as self-worth is not contingent upon achievement (Hall et al., 2007a). Conversely, when ego-involved athletes fail to demonstrate ability, self-worth is threatened, and repeated attempts at self-validation could promote dysfunctional patterns of achievement striving (Hall et al., 2007a). Therefore, both task and ego orientation may predict heavy training loads but ego goals may also foster a more intense and rigid approach to training. In support of these assertions, burnout in athletes has been positively related to ego orientation and inversely associated with task orientation (Lemyre et al., 2003). Potential causes of burnout include heavy physical training demands, insufficient recovery between workouts, and/or psychosocial stress (Raedeke, 2014).

Hypothesis 8

Running addiction has a direct, positive effect on self-reported upper respiratory tract infections.

Hypothesis 9

Running addiction has a direct, positive effect on self-reported running injuries.

Hypothesis 10

Training load has a direct, positive effect on self-reported upper respiratory tract infections.

Hypothesis 11

Training load has a direct, positive effect on self-reported running injuries.

Rationale for Hypotheses 8, 9, 10, and 11

Physiological conceptions of stress and models of exercise and infection imply that physical and/or psychosocial stressors can increase the risk of URTIs and overuse injuries in distance runners (Appaneal & Perna, 2014; Nieman, 2001; Selye, 1975). Hypothesized mediating mechanisms in this regard include stress-induced neuroendocrine changes leading to immunosuppression and impaired muscle repair ability (Appaneal & Perna, 2014). Since intense training and competition are both physically and psychologically demanding (Adams & Kirkby, 2001; Hancock & Hancock, 2014), it follows that heavier training loads may increase runners' susceptibility to infectious illness and injuries. Similarly, the compulsive and inflexible behaviour of addicted exercisers may enhance their exposure to psychosocial stress (Berczik et al., 2012) while simultaneously predicting greater physical training stress. Consequently, addicted exercisers may also be susceptible to overtraining and its adverse physical and psychological effects (Adams & Kirkby, 2001).

In support of these assertions, higher training volumes and marathon-type competitions have been linked to increased URTI incidence in several studies involving runners (Heath et al., 1991; Linde, 1987; Nieman et al., 1990b; Peters & Bateman, 1983; Peters et al., 1993; Robson-Ansley et al., 2012). There is also some evidence that overuse injury incidence is positively related to exercise/running addiction risk (Diekhoff, 1984; Ekenman et al., 2001; Layman & Morris, 1991; Lichtenstein et al., 2014; Rudy & Estok, 1989) and to specific dimensions of training load (Nielsen et al., 2012; Johnston et al., 2003; Ryan et al., 2006; van Gent et al., 2007).

Hypothesis 12

Running addiction has a direct, positive effect on training load.

Rationale for Hypothesis 12

Models of exercise addiction suggest that qualitatively harmful exercise behaviour is linked to heavier exercise loads. Individuals addicted to exercise are likely to train excessively and without limitations (Adams & Kirkby, 2001). More specifically, exercise addiction is expected to predict higher training frequency and intensity, and increased training volume over time (de Coverley Veale, 1987; Downs & Hausenblas, 2014; Hausenblas & Downs, 2002a; Rudy & Estok, 1989). Consistent with these ideas, positive associations between exercise addiction and training frequency, intensity, and/or duration have been observed in a number of investigations (Downs et al., 2004; Gapin et al., 2009; Hagan & Hausenblas, 2003; Hausenblas & Downs, 2002b; Iannos & Tiggemann, 1997; Layman & Morris, 1991; Lichtenstein et al., 2014; Terry et al., 2004; Youngman & Burnett, 2008).

Bivariate Correlations

In addition to the posited directional relationships described above, it was expected that several of the personality and motivational variables would be related to one another. These predicted associations were as follows:

Hypothesis 13

Perfectionism is positively related to Type A behaviour

Rationale for Hypothesis 13

Beliefs concerning the importance of high personal standards of achievement for self-validation and self-worth purposes purportedly underlie both the perfectionism and Type A constructs (Flett et al., 1994; Flett et al., 2011). Also, it has been maintained that perfectionism stems from high parental expectations and conditional acceptance (Frost et al., 1990). Similar parental influences on the development of Type A behaviour have been recognized. For example, it has been suggested that the parents of Type A individuals may be overly-demanding and castigatory (Flett et al., 1994). Therefore, it is plausible that these personality constructs are related. This assertion is supported by empirical research (Flett et al., 1994; Flett et al., 2011).

Hypothesis 14

Perfectionism is negatively related to task goal orientation.

Rationale for Hypothesis 14

The literature suggests that perfectionism typically predicts maladaptive achievement behaviour and outcomes (Bovornusvakool et al., 2012; D'Souza et al., 2011; Ellis, 2002; Flett & Hewitt, 2005; Hall et al., 2007a). Conversely, task goal orientation has been associated mainly with adaptive motivation-related behaviour (Biddle et al., 2003; Conroy & Hyde, 2014; Elliott & Dweck, 1988; Lemyre et al., 2003; Roberts et al., 1998; Roberts et al., 2007; Tenenbaum et al., 2005). Therefore, it is plausible that these variables may be inversely related in a distance running context.

Hypothesis 15

There is a positive correlation between task goal orientation and ego goal orientation.

Rationale for Hypothesis 15

According to the hierarchical model of achievement motivation, achievement goals can be differentiated on an approach–avoidance dimension, in addition to how competence is defined (Elliot & Thrash, 2001). In brief, therefore, goals may represent the motive to either attain competence (approach goals) or avoid incompetence (avoidance goals). This approach has yielded four sets of goals, specifically mastery-approach, mastery-avoidance, performance-approach, and performance-avoidance (Elliot & Thrash, 2001). Mastery-approach and performance-approach goals are equivalent to conceptions of task and ego goals in the dichotomous model (Roberts et al., 2007). This suggests that task and ego goals share an approach dimension, which could result in a positive relationship between the two goal orientations. Recent research is consistent with this idea (Hall et al., 2007a; Ozkan et al., 2012).

The set of research hypotheses described above was expressed in a conceptual model which was subsequently tested using the powerful, multivariate statistical technique of structural equation modelling (SEM). The proposed model is pictured in Figure 4.1. The single-headed arrows attached to straight lines in the diagram represent hypothesized direct effects, while the doubled-headed arrows attached to curved lines indicate predicted bivariate correlations. The technique of SEM is discussed in more depth later in this chapter.

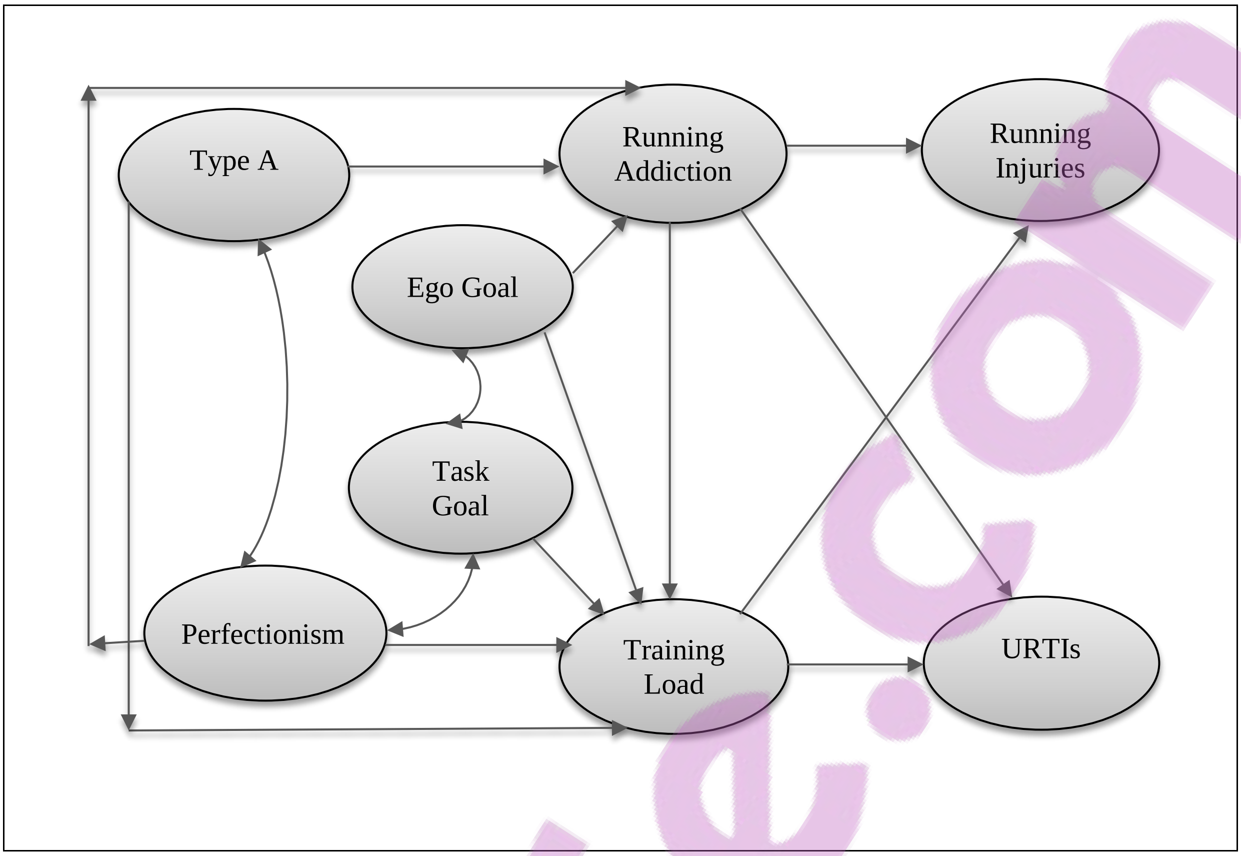

Figure 4.1. A Proposed Conceptual Model Relating Personality, Motivation, Running Addiction, Training Load, Running Injuries, and URTIs

Research Design

The present study employed a cross-sectional research design and utilized a self-report method of data collection. This constituted a self-administered, online questionnaire that featured a closed-ended response format. Consistent with a cross-sectional design, data were collected in one survey on a single occasion. This type of design can be contrasted with a longitudinal study, which involves multiple observations over time of the variables of interest (Fife-Schaw, 1998).

The current research design could also be termed, retrospective, in that the independent and dependent variables were assessed simultaneously. This approach differs from a prospective design in which the predictor variables are assessed weeks or months before the outcome variable(s) (Petrie & Falkstein, 1998).

Several considerations guided the selection of the current research design and method of data collection. An important concern was the need to obtain a sufficiently large sample to produce reliable results. In this regard, a cross-sectional design may have several advantages over a longitudinal design. For example, the former approach avoids the problem of subject attrition, which occurs when subjects drop out of the study while it is in progress (Fife-Schaw, 1998). Also, a cross-sectional survey places fewer demands on participants, which may enhance subject compliance (Fife-Schaw, 1998).

Similarly, self-report assessments of health and exercise may be more appropriate for the current purpose than certain alternative methods of data collection. These include physician ratings (Petrie & Falkstein, 1998) and the use of psychophysiological measures, such as heart rate monitors, to assess exercise intensity. Although ostensibly more objective than self-reports, these tools are likely to have financial and practical limitations when used for large-scale assessments. In contrast, the questionnaire method represents a simple and economical method of collecting health and exercise data for a large number of people. Furthermore, self-report measures of physical activity rate highly in the areas of acceptability, practicality, convenience, and information specificity (Hausenblas & Giacobbi, 2004). It has also been claimed that subjective measures of illness or injury are generally valid indicators of physical health status (Nowak, 1991). Moreover, self-report health assessments have been shown to have good construct and predictive validity (Molnar et al., 2006).

Research Participants and Sampling

A convenience sample consisting of 220 South African distance runners took part in the current study. Of these participants, 123 were male and 94 were female. Three respondents neglected to indicate their gender. A convenience sample has been defined as “a non-random sample that is chosen for practical reasons” (McBurney, 1998, p. 160). Participation criteria were that runners were aged 18 and older and took part in competitive running events of at least 800 metres in distance. The minimum age of participants was set at 18 in order to avoid the problem of obtaining parental consent.

The recruitment of participants incorporated several steps. First, a well-known South African road running website (i.e., http://www.runnersguide.co.za) was consulted in order to obtain a directory of athletic clubs countrywide. The next step was to identify clubs that have websites and thus may be reasonably large and have adequate communication networks. From this list, a total of 60 running clubs from across the country were selected.

Subsequent to this, an email was sent to club officials (e.g., secretary or chairperson) advising them of the study and requesting their assistance with the research. The designated individuals were asked to forward details of the study to their members and to attach the link to an online survey (https://www.surveymonkey.com). It was thought that the use of a ‘gatekeeper’ approach to subject recruitment (Barrett, 1998) could avoid the ethical and logistical problems associated with acquiring personal email addresses. A potential disadvantage of this strategy, however, is that the selected gatekeepers may fail to comply with the specific research request. A possible further problem is that gatekeepers may personally decide who should receive the survey, thus potentially biasing the sample of respondents (Barrett, 1998).

Several measures were taken in an effort to maximize the response rate. These included extending the survey response deadline and re-contacting gatekeepers to remind them about the study. A further strategy was to offer a pair of running shoes to the value of R1 200.00 as a lucky draw prize for participants. An attempt was also made to ensure that the survey was straightforward and could be completed within about 20 minutes. At the conclusion of the study, runners from 29 of the selected clubs (48%) had issued responses. Thus, it appeared that 52% of gatekeepers did not notify their members of the research for reasons that are subject to speculation. Of the responding clubs, 11 were based in Gauteng, nine in the Western Cape, eight in KwaZulu-Natal, and one in the Free State.

It should be noted that the use of an online survey may have resulted in a research sample that was more sophisticated and/or belonged to a higher socioeconomic bracket than the average runner. Therefore, the current sample may not be truly representative of the South African distance running population at large.

Ethical Considerations

In conducting the current investigation, every effort was made to ensure that the study complied with current international standards of conduct governing psychological research. In this regard, key ethical issues, such as informed consent, confidentiality, anonymity, voluntary participation, and subject debriefing, were identified and addressed. For example, respondents were advised of the nature and purpose of the study prior to participation. At the same time, they were assured of the confidentiality of all data collected, the anonymity of subjects, and the voluntary nature of involvement. An option was also provided for participants to receive feedback on the study results. Given the nature of the research, it was not foreseen that participation would impact negatively on the welfare of respondents. The Ethics Committee of the Department of Psychology at the University of South Africa provided ethical clearance for the study.

Measuring Instruments

Perfectionism

An adapted version of the Multidimensional Perfectionism Scale (MPS) (Frost et al., 1990) was used to measure the construct of perfectionism. The original instrument is a 35-item Likert-type scale that assesses factors hypothesized to be related to perfectionism. The measure consists of six subscales, namely Personal Standards, Concern over Mistakes, Doubts about Actions, Parental Criticism, Parental Expectations, and Organization.

Each of the six perfectionism subscales assesses a specific dimension of the construct. The Personal Standards subscale measures the tendency to strive for excessively high standards of performance, which form the basis of self-evaluation (e.g., “I set higher goals than most people”). The Concern over Mistakes scale assesses the inclination to associate mistakes with failure and negative social evaluations (e.g., “If I fail partly, it is as bad as being a complete failure”). The propensity for feelings of uncertainty and dissatisfaction in relation to completed tasks constitutes the Doubts about Actions scale (e.g., “Even when I do something very carefully, I often feel that it is not quite right”). The Parental Criticism and Parental Expectations scales measure the perception that one’s parents were overly critical and expected high levels of performance, respectively (e.g., “As a child, I was punished for doing things less than perfect”; and, “My parents wanted me to be the best at everything”). Finally, the Organization scale assesses the emphasis placed on neatness, order, and precision (e.g., “Organization is very important to me”). Respondents are instructed to indicate how much they agree with each statement using a five-point response format ranging from (1) *strongly disagree to* (5) *strongly agree.*

It has been shown that the overall perfectionism measure is both valid and reliable. For example, moderate to high correlations have been reported between the MPS and other measures of perfectionism, such as the Burns Perfectionism Scale and the Perfectionism Scale from the Eating Disorders Inventory (Frost et al., 1990). Moreover, the MPS has been found to correlate with diverse symptoms of psychopathology and with various compulsivity and procrastination measures (Frost et al., 1990). The scale's internal consistency reliability has also been demonstrated. For instance, the authors reported a Cronbach *alpha* of 0.90 for the total perfectionism measure, and reliability coefficients above 0.80 for each of the subscales, except Doubts about Actions (0.77) (Frost et al., 1990).

In the present study, five of the six subscales were used to assess the construct of perfectionism. The subscale, Organization, was excluded from the analysis as it has been found to have the weakest correlations with the other subscales and alternative perfectionism measures. Consequently, it has been proposed that organization is not a key dimension of perfectionism (Frost et al., 1990). In previous research, the exclusion of the Organization subscale did not affect the reliability of the overall perfectionism measure (Frost et al., 1990).

The five remaining subscales were used to form three separate variables that served as indicators of the perfectionism factor in a proposed structural equation model. These measured or observed variables were labelled (1) perfectionistic strivings, (2) perfectionistic concerns, and (3) parental perceptions. A brief description of each indicator is provided below.

Perfectionistic Strivings

Perfectionistic strivings represented the achievement striving dimension of perfectionism. Therefore, the score for this variable corresponded to the score obtained on the Personal Standards subscale of the MPS. Total possible scores ranged from 7 to 35.

Perfectionistic Concerns

This observed variable comprised those dimensions of perfectionism that have been identified as maladaptive in nature. A score for perfectionistic concerns was obtained by adding together scores for the Concern over Mistakes and Doubts about Actions subscales of the MPS. Total possible scores ranged from 13 to 65.

Parental Perceptions

This indicator consisted of those aspects of perfectionism related to perceptions about imposed parental standards of performance. Scores for the Parental Expectations and Parental Criticism subscales were added together to obtain an overall score for this variable. Total possible scores ranged from 9 to 45.

Type A Behaviour Pattern

The Type A Self-Rating Inventory (TASRI) (Blumenthal et al., 1985) was used to assess Type A behaviour pattern. This instrument is a brief 28-item self-report measure based on a set of descriptors judged to be relevant to the Type A construct.

A total of 21 of the scale items directly characterize the Type A behaviour pattern (e.g., “Energetic”, “Self-Confident”, “Enterprising”), while a further seven items typify the Type B behaviour pattern (e.g., “Quiet”, “Easy-Going”, “Calm”). Using a seven-point Likert-type response format, respondents are instructed to indicate how true of themselves these characteristics are. Response options range from (1) *never or almost never true* to (7) *always or almost always true.* A total score for the Type A construct is obtained by adding together scores for the 21 Type A items and the seven converted Type B items (Type B items are transformed by subtracting each response from eight). Therefore, scores for this measure range from 28 to 196. In the present study, dictionary-based definitions were provided for each of the adjectives in order to clarify their meaning and avoid misinterpretation (e.g., “Irritable: easily annoyed/angered”; “Dominant: having control/influence”).

It has been stated that the TASRI is easy to administer and score, which makes it particularly suitable for screening large numbers of subjects for clinical or research purposes (Blumenthal et al., 1985). Furthermore, the measure has been shown to correlate positively with other established Type A instruments. These include the Jenkins Activity Survey and an independent behavioural rating based upon a standard structured interview (Blumenthal et al., 1985). Thus, there is evidence to support the inventory's concurrent validity. A test-retest reliability coefficient of 0.88 has been reported (Blumenthal et al., 1985).

Achievement Goal Orientations

The adult version of the 12-item Perception of Success Questionnaire (Roberts et al., 1998) was used to assess achievement goal orientations. This measure was developed specifically for the sport context over a 10-year period. The instrument consists of two six-item five-point Likert-type subscales that assess the individual's endorsement of task and ego goals, respectively, in sporting domains (Roberts et al., 1998).

In completing the questionnaire, respondents are asked to indicate what success in sport means to them. An example of a statement from the ego goal subscale is, "When playing sport, I feel most successful when I beat other people". An example from the task goal subscale is, "When playing sport, I feel most successful when I reach personal goals". Response options range from (1) *strongly disagree* to (5) *strongly agree*, while total scores for each goal orientation range from 6 to 30.

Both measures have strong psychometric properties. The authors have reported internal reliability coefficient *alphas* of 0.82 for the task subscale and 0.87 for the ego subscale. Test-retest reliabilities of 0.80 for task orientation and 0.78 for ego orientation have also been noted (Roberts et al., 1998). Moreover, the instrument has been shown to have strong construct and concurrent validity (Roberts et al., 1998). In addition, the results of confirmatory factor analysis have served to confirm the hypothesized underlying two-factor structure of the measure (Roberts et al., 1998).

Running Addiction

The Exercise Addiction Inventory – Short Form (EAI) (Terry et al., 2004) was used to assess the construct of running addiction. This instrument is a brief screening tool that is based on the tenets of behavioural addiction proposed by Griffiths (1996, 1997). Consistent with this approach, the instrument incorporates the dimensions of salience, mood modification, tolerance, withdrawal symptoms, conflict, and relapse.

The EAI consists of six statements with a five-point Likert-type response format that measure each of the six hypothesized components of behavioural addiction. For example, the statement, “I use exercise as a way of changing my mood (e.g., to get a buzz, to escape etc.)” assesses the concept of mood modification. The item, “If I have to miss an exercise session, I feel moody and irritable”, measures the dimension of withdrawal symptoms. Response options for each statement range from (1) *strongly disagree* to (5) *strongly agree*. The maximum achievable score for the measure is 30. Higher scores indicate a greater risk for exercise addiction, with respondents scoring above 24 (i.e., within the top 15%) considered to be at risk for the disorder. The score range indicative of symptomatic and asymptomatic individuals is 13 to 23, and 6 to 12, respectively (Terry et al., 2004).

For the purposes of the current study, the reference to “exercise” in the inventory was replaced with the term, “running”. For example, the statement, “Exercise is the most important thing in my life”, was replaced with the statement, “Running is the most important thing in my life”.

The EAI is simple to administer and score and has been demonstrated to have sound psychometric properties. Specifically, the authors reported an internal consistency reliability coefficient (Cronbach *alpha*) of 0.84 for the measure. It has been shown that the instrument also has excellent concurrent validity. In this regard, the EAI was found to correlate strongly with two other measures that appear to assess problem exercise, the Obligatory Exercise Questionnaire and the Exercise Dependence Scale (Terry et al., 2004). Moreover, in support of its construct validity, the EAI was able to distinguish between high and low exercise frequencies among regular exercisers. It has been shown that the measure also has good content validity (Terry et al., 2004).

Training Load

A self-report checklist measure of customary training and competition behaviour, as well as a short rating scale designed to measure recovery-related practices, was used to assess training load. This approach was in line with Kellmann & Altfeld’s (2014a) conception of training load in terms of factors like training volume and intensity, frequency of competitions, and the stress-recovery relationship.

Respondents were asked to provide information in relation to training patterns during both heavier and lighter training periods. Heavier training periods were defined as pre-competition training phases, while lighter training periods were described as post-race recovery periods. This distinction was made in the event that training patterns varied across time and context. The following training dimensions were assessed: (1) total weekly running distance, (2) total number of runs per week, (3) number of runs under and over 90-minutes' duration, respectively, (4) number of easy runs, (5) number of medium-intensity runs, (6) number of hard runs, and (7) number of very hard runs. A range of response options were provided for each category. For example, for the category, total weekly running distance, 11 response options, ranging from *less than 30 kilometres* and increasing in 10 kilometre increments (e.g., *31 – 40 kilometres*) to *120 kilometres or more*, were listed. For total number of runs, the response options ranged from *1* to *10 or more*, while for the remaining categories, options varied between *0* and *10 or more*.

Participants were also requested to supply data concerning the average number of races of different distances run per year. Anecdotal evidence and personal experience suggests that each runner tends to participate in a similar number of races every year. In order to assess this dimension, seven categories of races, based mainly on standard distances, were listed. These ranged from events of *800 – 3 000 metres* (track events) to races of *85 – 90 kilometres* (e.g., the Comrades Marathon). Also included was a category labelled *other* where respondents could specify race distances that were not listed.

A 10-item Likert-type rating scale, constructed by the author, was used to assess recovery-related practices. The specific purpose of this instrument was to measure the extent to which respondents are inclined to train hard despite experiencing symptoms suggesting inadequate recovery from previous strenuous efforts. Physical indications of insufficient rest include lethargy, muscular pain and stiffness, performance impairment, injuries, and minor infections. Theoretically, prolonged underrecovery may increase the risk for the overtraining syndrome, injuries, and respiratory infections (Kellmann & Altfeld, 2014b).

In completing this questionnaire, respondents were asked to indicate their typical approach to training and competition by choosing the option that best described their normal behaviour. The scale consisted of statements such as, "I would try to 'run through' symptoms of pain or injury," and, "I would train hard or race even if I did not feel up to it physically'. Response options ranged from (1) *strongly disagree* to (5) *strongly agree*. However, half of the items were negatively coded so that *strongly disagree* was allocated a score of 5, and *strongly agree* was assigned a score of 1. Examples of these statements were, “I would rest or do a short easy run if I felt particularly tired or sluggish”, and, “I would abandon a training run if any muscle soreness persisted or worsened”.

The totality of data collected pertaining to training and competition patterns was used to create four indicators of the latent variable (factor) of training load in a structural equation model: (1) training workload, (2) training frequency, (3) competition frequency, and (4) underrecovery. A description of each variable is provided below.

Training Workload

This indicator represented a combined estimate of the average weekly amount and intensity of training. An index of training workload was obtained by multiplying the score for training volume by the score representing level of exertion. The score for training volume corresponded to the mean value of the respective running distance categories, rounded off to the lower number (e.g., *51 – 60 kilometres* = 55). (For the category, *120 kilometres or more*, a quantity of five was added to obtain a score of 125). A score for training intensity or exertion was calculated as follows: (number of easy runs × 2) + (number of medium-intensity runs × 3) + (number of hard runs × 4) + (number of very hard runs × 5) / total number of weekly runs. These computations were performed for both heavier and lighter training periods, from which a mean score was calculated.

This conception of training workload was based on the ideas of Edwards and Burke (as cited in Noakes, 2001). Specifically, the authors maintained that training workload could be quantified by multiplying exercise duration by a value corresponding to its intensity. The intensity of exercise was, in turn, determined by a combination of objective and subjective criteria. The authors identified five training zones that could be differentiated on the basis of both actual (e.g., percentage of maximum heart rate) and perceived level of effort (i.e., subjective rating). These training categories were labelled, *healthy heart*, *temperate*, *aerobic*, *threshold*, and *red line*, and were numbered 1 to 5, respectively. Thus, an index of training workload could be established by multiplying training duration by the relevant training zone. The actual and perceived level of effort associated with each training zone, as well as an example of the type of activity that falls within each category, is shown in Table 4.1. The equivalent terms used for the different training categories in the current study were as follows: zone 2 = *easy run*; zone 3 = *medium-intensity run*; zone 4 = *hard run*; zone 5 = *very hard run*. Zone 1 was excluded on the basis that it is not relevant to jogging/running.

In other research, training intensity has frequently been operationalized as running pace or speed (Nielsen et al., 2012). However, this approach does not take into account relative intensity, or perceived exertion, which could arguably be more relevant for health outcomes. For example, for runners of high ability, a training pace of four minutes per kilometre could be perceived as an easy run. Conversely, for the average runner, such a pace would be deemed a very hard run, if achievable at all, and would be far more physiologically demanding.

Table 4.1

Aerobic Exercise Training Zones (Adapted from Noakes, 2001, p. 359)

Training Zone	Percentage of Maximum Heart Rate	Subjective Rating of Perceived Exertion	Example of Activity
1 = Healthy Heart	50 - 60%	Very Light	Walking
2 = Temperate	60 - 70%	Fairly Light	Jogging (slow running)
3 = Aerobic	70 - 80%	Somewhat hard	Running
4 = Threshold	80 - 90%	Hard	Fast running
5 = Red Line	90 - 100%	Very hard	Very fast running

Training Frequency

This indicator represented the typical regularity of training sessions. Participants' scores for this variable corresponded to the reported number of runs usually undertaken each week across heavier and lighter training periods.

Competition Frequency

This measured variable reflected participants' habits with respect to race participation. A score for this indicator was obtained by tallying the number of events of various distances run on average each year. For the final analyses, only races of four kilometres and longer were included.

Underrecovery

The underrecovery indicator provided an estimate of the extent to which respondents are inclined to continue with hard training despite experiencing symptoms of residual physical strain. A score for this variable was obtained by summing participants' responses to the 10-item measure of recovery-related practices, as previously described. Total possible scores ranged from 10 to 50, with higher scores implying a stronger inclination to persist with training despite indications that further rest is required.

Running Injuries

A self-report checklist pertaining to recent occurrences of running-related pain, in combination with a self-constructed measure that was based on the Physical Health Questionnaire (PHQ) (Schat, Kelloway & Desmarais, 2005), was used to assess running injuries.

First, respondents were asked to indicate whether they had experienced running-related pain in one or more common injury sites in the previous three months. They were required to check the appropriate box (*yes/no*) for this purpose. In line with frequently-reported injury locations, the injury areas listed were the lower back, hip, pelvis, groin, buttock, upper leg, knee, lower leg, ankle, and foot (Ellapen et al., 2013; Noakes & Granger, 2003; Ryan et al., 2006; van Gent et al., 2007). If this question was answered in the affirmative, then participants were asked to describe the severity and duration of self-reported pain and to indicate the duration of any pain-related training disruptions for each injury site. For the categories, pain duration and pain-related training time loss, five response options were provided: *1 – 7 days, 8 – 14 days, 15 – 21 days, 22 – 28 days, and 29 days or more*. In order to rate pain severity, a four-point scale that listed the following alternatives was provided:

1 = *Felt pain after running only*

2 = *Felt pain during running that did not affect distance or speed*

3 = *Felt pain during running that affected distance and speed*

4 = *Felt pain that prevented all running*

This approach was derived from the conceptualization of running injury severity in terms of level of debilitation (Noakes, 2001). It has been suggested that running injuries progress through four stages of severity and can be graded accordingly. With each subsequent stage, the injury becomes increasingly debilitating. For example, grade 1 and 2 injuries have no discernible impact on training or performance, whereas grade 3 and 4 injuries can significantly affect exercise capacity. The four severity ratings in the present study were intended to represent the different grades of injury.

A four-item rating scale, based on the language and format of the PHQ (Schat et al., 2005), was constructed by the author in order to assess running injuries further. The PHQ is a seven-point, Likert-type instrument that measures the incidence of somatic symptoms over a specified time period. Four dimensions of physical health are assessed, specifically digestive disorders, sleep problems, headaches, and respiratory infections. Respondents are asked a number of questions in order to determine their recent physical health status. An example of an item from the digestive disorders subscale is, “How often have you suffered from an upset stomach (indigestion)?” Response options range from (1) *not at all* to (7) *all of the time*.

Using a similar approach and response-format, participants in the present study were questioned about the incidence of running-related pain over the preceding 12 months and the impact of such events on training and performance. Questions included, “How often have you felt pain in any of the muscles, joints, etc. of your lower body during or after running?” and, “How often have you had to reduce your training due to running-related pain or discomfort?” Consistent with the response format of the PHQ, response options ranged from (1) *not at all* to (7) *all of the time*.

Although self-reports of running-related pain do not confirm the presence of injury, it can be argued that they are strongly suggestive of injury. Moreover, pain or discomfort is an integral component of running injuries, as implied by the injury severity rating approach (Noakes, 2001) and as further observed in injury diagnostic charts (Noakes & Granger, 2003).

The totality of data collected relating to injury occurrences was used to create five indicators of the factor, running injuries, in a structural equation model: (1) injury number, (2) injury severity, (3) injury duration, (4) injury-related training time loss, and (5) injury history. Each variable is briefly described below.

Injury Number

As the name implies, this indicator reflected the quantity of running-related pain occurrences in the preceding three-month period. A score for this variable was obtained by simply tallying the number of different injury sites that had been linked to pain events. For example, if pain had been experienced in both the lower leg and buttock, then a score of 2 was assigned for this variable. A score of 0 indicated that no pain incidences had been reported.

Injury Severity

This variable provided an indication of the average level of debilitation associated with running-related pain. The score for this indicator corresponded to the subjective severity ratings assigned to specific pain occurrences on a scale of 1 to 4, as described earlier. If pain had been experienced in more than one location, then the mean of the set of ratings was allocated. For example, if three areas of pain had been reported with corresponding severity scores of 1, 2, and 3, then a score of 2 would be assigned for injury severity (i.e., (1 + 2 + 3) / 3). A score of 0 indicated that no incidences of running-related pain had been reported.

Injury Duration

The injury duration indicator portrayed the average number of days that running-related pain had persisted. In each case, the median or midmost value of the relevant time range was utilized (e.g., *1 – 7 days* = 4). (The response, *29 days or more*, was assigned a score of 32 i.e., seven points higher than the previous number in the series). If pain had been experienced in more than one location, then the mean of the set of scores was assigned. For example, if two areas of pain had been reported with corresponding pain duration scores of 11 and 18, then the injury duration score would be 14.5 (i.e., (11 + 18) / 2). A score of 0 implied that no incidences of running-related pain had been reported.

Injury-Related Training Time Loss

This variable reflected the total duration, in days, of self-reported pain-related training stoppages. In each case, the median or midmost value of the relevant time range was utilized (e.g., *15 – 21 days* = 18). (The response, *29 days or more*, was assigned a score of 32). If pain had been experienced in more than one location, then the total value of the set of scores was assigned. For example, if three areas of pain had been reported with corresponding training stoppage scores of 4, 18, and 25 days, then the injury-related training time loss score would be 47 (i.e., 4 + 18 + 25). A score of 0 indicated that no pain-related training stoppages had been reported.

Injury History

The injury history indicator provided an estimate of running-related pain occurrences over the previous 12 months. A score for this variable was obtained by summing responses to the four-item running injury rating scale, as described earlier. Total scores ranged from 4 to 28, with higher scores reflecting more frequent and more incapacitating episodes of running-related pain during this period.

Upper Respiratory Tract Infections

A self-report checklist in relation to recent episodes of upper respiratory tract infections, together with a modified version of the respiratory illness subscale of the PHQ (Schat et al., 2005), was used to assess URTIs.

First, respondents were asked to indicate whether they had experienced any infections such as colds, flu, coughs, or sore throats in the previous three months. They were required to check the appropriate box (*yes/no*) for this purpose. If this question was answered in the affirmative, then information was elicited concerning the number, severity, and duration of infections. If more than one URTI was experienced, then an average severity and duration rating across episodes was requested. Participants also provided information pertaining to the duration, in days, of any URTI-related training disruptions. In order to rate infection severity, a three-point scale that featured the following response options was provided:

1 = *Infection was mild (i.e., did not restrict daily routine or activities)*

2 = *Infection was moderate (i.e., restricted daily routine or activities somewhat)*

3 = *Infection was severe (i.e., restricted daily routine or activities significantly)*

Three response options were also listed in relation to the number of infectious episodes experienced (i.e., *1*, *2*, and *3*). For the dimension of URTI duration, participants were able to choose from one of the following options: *2 – 3 days*, *4 – 5 days*, *6 – 7 days*, *8 – 9 days*, and *10 days or more*. The response options provided for the time loss measure were, *1 – 7 days*, *8 – 14 days*, *15 – 21 days*, *22 – 28 days*, and *29 days or more*.

A four-item adapted version of the respiratory illness subscale of the PHQ (Schat et al., 2005) was used to assess URTI further. As mentioned, the PHQ is a seven-point, Likert-type instrument that measures somatic symptom occurrences over a specified time period. Three of the scale items have been designed to assess respiratory problems. An example is, "How often have you had minor colds (that made you feel uncomfortable but didn't keep you sick in bed or make you miss work/school)?"

For the purposes of the present study, two of the respiratory items were included in a modified measure of URTI, along with two new items that were composed by the author. These items were designed to assess the incidence of respiratory infections over the preceding 12 months and their effect on training and performance. An example was, "How often have respiratory infections disrupted your training?" Consistent with the response format of the PHQ, response options ranged from (1) *not at all* to (7) *all of the time*.

The totality of data collected relating to upper respiratory infectious episodes was used to create five indicators of URTI in a structural equation model: (1) URTI number, (2) URTI severity, (3) URTI duration, (4) URTI-related training time loss, and (5) URTI history. Each observed variable is briefly described below.

URTI Number

This indicator simply represented the self-reported number of URTI occurrences in the preceding three-month period. Possible scores for this variable ranged from 0 to 3. A score of 0 indicated that no URTIs had been reported.

URTI Severity

The URTI severity indicator provided an estimate of the average severity of infectious episodes or, more specifically, the extent to which URTIs had limited daily functioning. The score for this variable corresponded to the average subjective ratings assigned to infectious episodes on a scale of 1 to 3, as described previously. A score of 0 indicated that no infections had been reported.

URTI Duration

This variable depicted the average number of days that infectious episodes had lasted. In each case, the mean of the relevant time range was utilized (e.g., *2 – 3 days* = 2.5). (The response, *10 days or more*, was assigned a score of 10.5). A score of 0 indicated that no URTI occurrences had been reported.

URTI-Related Training Time Loss

This indicator reflected the total duration, in days, of self-reported URTI-related training disruptions. In each case, the median or midmost value of the relevant time range was utilized (e.g., *8 – 14 days* = 11). (The response, *29 days or more*, was assigned a score of 32). A score of 0 indicated that no URTI-related training stoppages had been reported.

URTI History

The URTI history variable provided an estimate of URTI incidence over the previous 12 months. A score for this indicator was obtained by summing responses to the modified four-item respiratory subscale of the PHQ, as described previously. Total scores ranged from 4 to 28, with higher scores reflecting more frequent and more troublesome infectious episodes during this period.

Demographic and Additional Information

Information was collected on a number of other variables of interest, including age, gender, population group, and level of athletic performance (e.g., national level, provincial level, basic level, etc.). Further, respondents were asked to indicate the number of years they had participated in the sport and how often they kept a record of their running activity. Data were also elicited in relation to participants' involvement in other endurance activities, such as cycling and swimming, and their susceptibility to allergies like hay fever.

A copy of the research survey is included as Appendix A.

Techniques of Statistical Analysis

As mentioned previously, the research hypotheses were tested using the multivariate statistical technique of structural equation modelling. SEM has been described as a flexible and comprehensive tool for examining complex interrelationships among multiple variables (Waters et al., 2007). The main purpose of SEM is to allow researchers to test causal theories using nonexperimental data (Martin, 1987).

SEM fundamentally comprises a suite of statistical methods for modelling data (Hoyle, 2012). In its general form, it consists of two components, specifically a structural and a measurement model (Fabrigar & Wegener, 2014; Klem, 2000). These components are analogous to path and confirmatory factor analytic models, respectively (Klem, 2000). In most studies where SEM is employed, however, the structural model is of primary interest, and the measurement model is usually less important (Fabrigar & Wegener, 2014; Marsh, 2007). Special applications of SEM involve either only the measurement model or just the structural model (Fabrigar & Wegener, 2014; Klem, 2000).

In broad terms, SEM is used to represent and estimate hypothesized relations among factors and between factors and measured variables (Fabrigar & Wegener, 2014). Factors are the unmeasured or latent variables that reflect abstract concepts in the model (Klem, 2000). The specified pattern of relations among factors is represented in the structural model, while the relations between latent and measured variables are reflected in the measurement component of the model (Fabrigar & Wegener, 2014; Klem, 2000).

The specified relations among factors in the structural model may be directional or nondirectional (Hoyle, 2012). A directional relation expresses the effect of one variable on another. A directional path has been described as, "the amount of change in a dependent variable attributable to an independent variable controlling for other relations in the model" (Hoyle, 2012, p. 340). SEM may be used to test a variety of causal relations among variables, including direct and mediational causal effects (Fabrigar & Wegener, 2014). In mediation, a third variable is posited to intervene between the independent and dependent variables (Fabrigar & Wegener, 2014). Mediating variables are assumed to explain the independent-dependent variable relation (Biddle & Marlin, 1987). Aside from directional effects, SEM may be used to assess posited nondirectional paths, or covariances, between two variables in the structural model (Hoyle, 2012).

Whereas the structural model in SEM focuses on the relations among factors or constructs, the measurement model expresses the relations between factors and measured variables (Fabrigar & Wegener, 2014; Klem, 2000). More specifically, the measurement model describes the pattern of relations between measured variables and the factors that they are designed to represent (Anderson & Gerbing, 1988; Marsh, 2007). This set of relations expresses the assumption that a single latent construct accounts for the covariance among a set of measured variables, or indicators (Klem, 2000).

A key strength of SEM is the inclusion of multiple indicators for each latent variable (Brookings & Bolton, 1997). This, in turn, increases the reliability of the regression estimates in the structural model (Brookings & Bolton, 1997; Marsh, 2007). Optimally, there should be at least three indicators per factor (Marsh, 2007). However, in some instances only a single indicator of a specific construct is available (Anderson & Gerbing, 1988). In this case, the measured variable itself may be included in the structural part of the model in order to represent the construct of interest (Fabrigar & Wegener, 2014).

Apart from measured and unmeasured variables, structural equation models include both exogenous and endogenous variables, which are model-dependent (Klem, 2000; Marsh, 2007). Variables that are not explained by the specified model are referred to as exogenous variables. Conversely, it is assumed that endogenous variables are determined or caused by one or more other variables in the proposed model (Klem, 2000; Marsh, 2007). Also termed independent and dependent variables, respectively, both exogenous and endogenous variables may be either measured or unmeasured (Klem, 2000).

SEM is considerably more flexible than traditional multivariate statistical methods (Hoyle, 2012). However, certain statistical assumptions about the study data are inherent in traditional SEM statistical packages (Klem, 2000; Marsh, 2007). For instance, maximum likelihood (ML) estimation, which is the predominant estimation method in SEM, assumes that the study data have a multivariate normal distribution (Fabrigar & Wegener, 2014; Klem, 2000; Marsh, 2007). However, multivariate normality is seldom observed in social science studies or in sport and exercise psychology research (Klem, 2000; Marsh, 2007). Still, in most cases, ML appears to be robust against violations of normality (Anderson & Gerbing, 1988; Klem, 2000; Marsh, 2007).

The size of the research sample is also of relevance when using SEM (Klem, 2000; Marsh, 2007; Whittaker, 2012). Although large samples are favoured, the costs of acquiring larger samples should be weighed against the prospective benefits this provides (Marsh, 2007). These are likely to be study specific (Marsh, 2007). Scholars have recommended a ratio of five to 10 participants for each parameter estimated (Klem, 2000). However, characteristics of the specified model and various statistical factors influence the number of cases needed for reliable results (Klem, 2000). For example, larger samples are necessary when the model is complex, there are few indicators per factor, the variable distribution is nonnormal, and the magnitude of the coefficients is weak (Klem, 2000).

The conduct of structural equation modelling can be conceptualized in terms of three broad stages (Hoyle, 2012; Klem, 2000; Marsh, 2007). These phases have been described as model specification, parameter estimation, and model fit evaluation, respectively (Hoyle, 2012; Marsh, 2007). The first of these stages involves the specification of an a priori model, which is based on theory and satisfies certain SEM technical criteria (Marsh, 2007). Hoyle (2012) has stated that "the goal of model specification is the identification of a model that is testable and useful, even if it fails to account for all aspects of the reality that produced the data" (p. 339). The specification of a model may take the form of a path diagram or a series of equations (Klem, 2000). The second stage of SEM, parameter estimation, describes the generation of a set of coefficients that represent directional and nondirectional relations in the specified model (Klem, 2000; Marsh, 2007). Finally, the evaluation of model fit constitutes an assessment of the extent to which the hypothesized model corresponds to the sample data (Byrne, 2001; Klem, 2000; Marsh, 2007).

The balance of this chapter will be devoted to describing the process of model specification in accordance with the specific objectives of the present study. The steps of parameter estimation and model evaluation will be discussed in greater depth in the following chapter.

Model Specification

Consistent with SEM convention, the modelling process in the present study commenced with the specification of a full structural equation model that represented the hypothesized network of relations among the set of study variables. The proposed model took the form of a path diagram that is pictured in Figure 4.2.

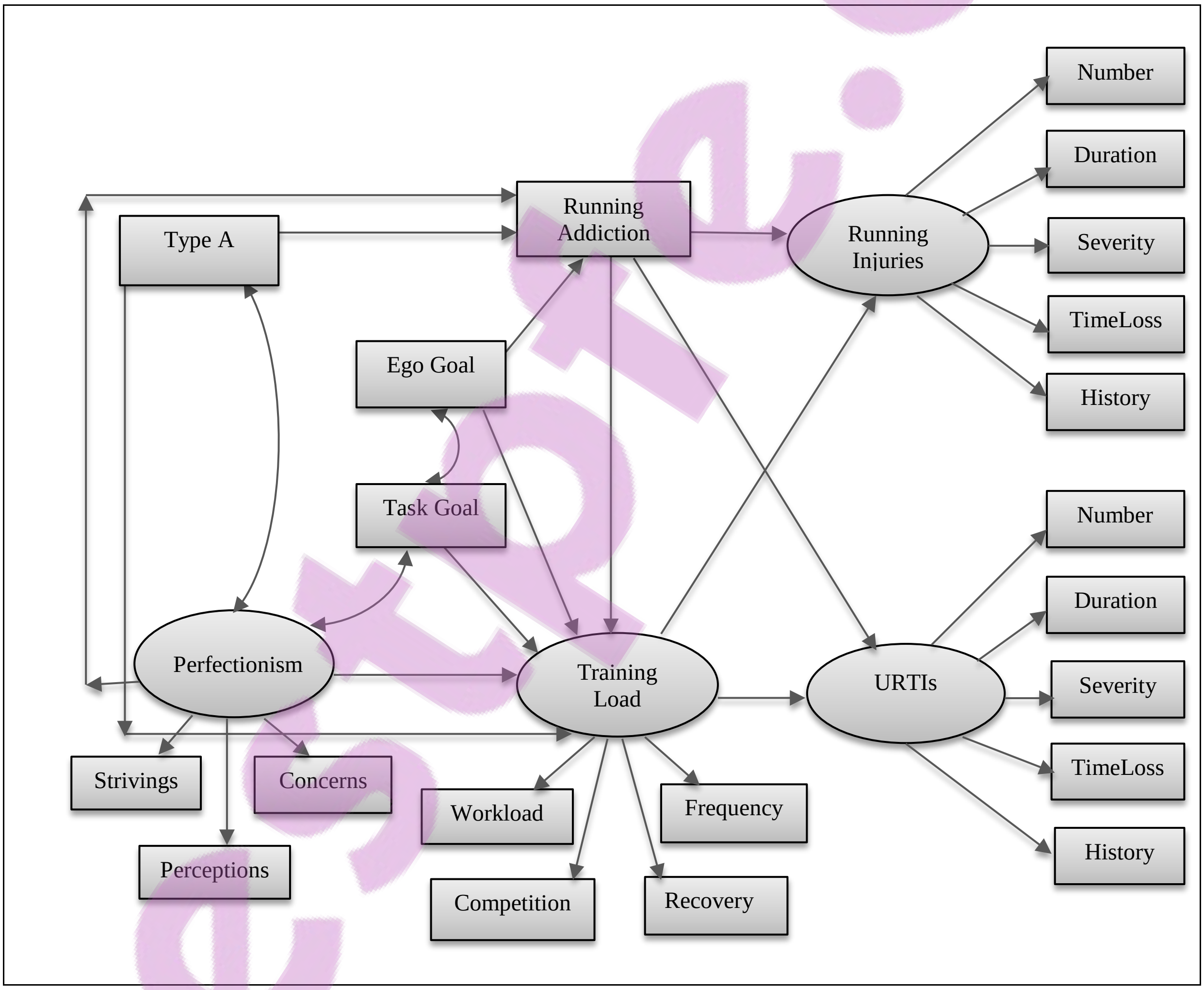

Figure 4.2. A Proposed Structural Equation Model of Personality, Motivation, Running Addiction, Training Load, Running Injuries, and URTIs

In the depicted model, ellipses and rectangles represent the latent and measured variables, respectively (Byrne, 2001). Straight lines with single-headed arrows denote hypothesized directional relationships, while curved lines with double-headed arrows represent nondirectional, covariances.

Variables in the Model

The specified model encompassed a total of 50 variables, comprising 21 measured variables and 29 unmeasured variables. Each of the observed (measured) variables represented a specific latent construct (unmeasured variable) in the model. For example, perfectionistic concerns, perfectionistic strivings, and parental perceptions served as indicators of perfectionism, while specific measures of training and competition habits were used to reflect training load. A further set of measured variables pertained to the running injury and URTI constructs, respectively. These variables related to specific dimensions of injuries and URTIs, such as self-reported incidence, duration, severity, history, and associated training time loss. The four remaining measured variables in the model were running addiction, Type A behaviour, ego goal orientation, and task goal orientation. Each of these variables represented a latent construct that had been assigned a single indicator (i.e., a scale score). In this case, the measured variable was used in the analysis. This approach is mathematically equivalent to specifying a latent variable with a single indicator (Fabrigar & Wegener, 2014). Finally, as it was assumed that each measured variable in the proposed model was influenced by its underlying factor, these variables were classified as endogenous variables.

As already alluded to, the unobserved variables in the specified model included perfectionism, training load, running injuries, and URTIs. The latter three factors could be classified as endogenous variables since they were assumed to be influenced by other variables in the model. Perfectionism served as a predictor variable and thus could be labelled an exogenous factor. The 25 remaining unmeasured variables represented various sources of error in the measured and unmeasured variables. (The error terms are not depicted in the path diagram). In SEM, the error associated with a variable includes the effects of both measurement error and variables absent from the model (Klem, 2000). Measurement errors are also referred to as residual variance or disturbance terms (Marsh, 2007). Since the origin of error is not specified in the model, error variables are exogenous variables.

Model Components

Consistent with the characteristics of a general SEM model, the specified model comprised both a structural and measurement component. However, the structural submodel (which is equivalent to the conceptual model shown in Figure 4.1) constituted the primary focus of the research. The main purpose of the measurement submodel was to determine whether the measured variables or indicators adequately reflected their corresponding latent constructs (Hoyle, 2012).

As illustrated in Figure 4.2, the proposed structural submodel expressed the hypothesized network of directional and nondirectional relations among the eight latent variables in the study. These predicted relations pertained to the effects of perfectionism, Type A behaviour, and achievement goal orientations on running addiction and training load, the impact of running addiction on training load, and their influence, in turn, on URTIs and running injuries. The specified model also described the hypothesized nondirectional, covariances among specific personality and motivation variables. These included the predicted correlations between perfectionism and Type A behaviour, task and ego goal orientation, and perfectionism and task goal orientation.

The measurement component of the hypothesized model represented the pattern of relations between the measured variables and their respective underlying latent constructs. These relations pertained to the effects or factor loadings of perfectionism, training load, running injuries, and URTIs on their corresponding indicators, as previously enumerated.

The specified full structural equation model was subsequently tested using IBM SPSS Amos 22.0 statistical software. In addition to the SEM analysis, the current research data were analysed using descriptive and correlational statistical techniques. The results yielded by these different methods of statistical analysis are presented in the following chapter.

CHAPTER 5

RESULTS

The broad aim of this study was to explore the relationships among personality traits, motivation, running addiction, training load, running injuries, and upper respiratory tract infections (URTIs). As discussed in the previous chapter, a review of the relevant literature led to the formulation of a number of research hypotheses that specified how the study variables were related. This set of predictions was subsequently expressed in a structural equation model that was presented in the form of a path diagram (see Figure 4.2).

To reiterate, the specified model constituted a hybrid of confirmatory factor analysis and path analysis. The confirmatory factor analysis or measurement part of the model expressed the relations of the observed variables to their underlying latent constructs. Specifically, the measurement submodel represented the effects or loadings of perfectionism, training load, URTIs, and running injuries on their respective indicators. The path analysis or structural component of the model described the posited network of directional and nondirectional relations among the constructs of interest (Anderson & Gerbing, 1988). These predicted relations included the effects of the personality and motivation variables on running addiction and training load and the impact of the latter variables, in turn, on URTIs and running injuries. This portion of the model also represented the hypothesized covariances among the predictor variables.

Further to the primary SEM analysis, the study data were analysed using descriptive and correlational statistical techniques. The results yielded by these various methods of statistical analyses are presented and delineated in this chapter.

Descriptive Statistical Analysis

Participant Characteristics

A total of 221 distance runners who were members of 29 different South African athletic clubs completed the online survey that formed part of the present study. However, one respondent complied only partially with the research requirements in that a limited number of measures were completed. Consequently, this individual was not included in the statistical analyses. Therefore, the final research sample consisted of 220 participants, comprising 123 males (56%) and 94 females (42.7%). Three respondents (1.3%) did not indicate their gender group.

Figure 5.1 portrays the age-related heterogeneity of the research sample. As shown, the study participants exhibited wide age diversity with an age range of at least 50 years between the youngest and oldest respondents. Most of the participants (59.5%), however, were between the ages of 30 and 49. Of this group, 66 runners (30%) were aged 30 to 39, and 65 respondents (29.5%) were between 40 and 49 years-old. A further 42 members of the sample (19.1%) were between the ages of 20 and 29, and another 31 runners (14.1%) were 50 to 59 years-old. Of the balance, three participants (1.4%) were aged 18 or 19, and 10 individuals (4.5%) were 60 years-of-age or older. Two of these runners were in their seventies. Three participants did not provide data relating to this variable.

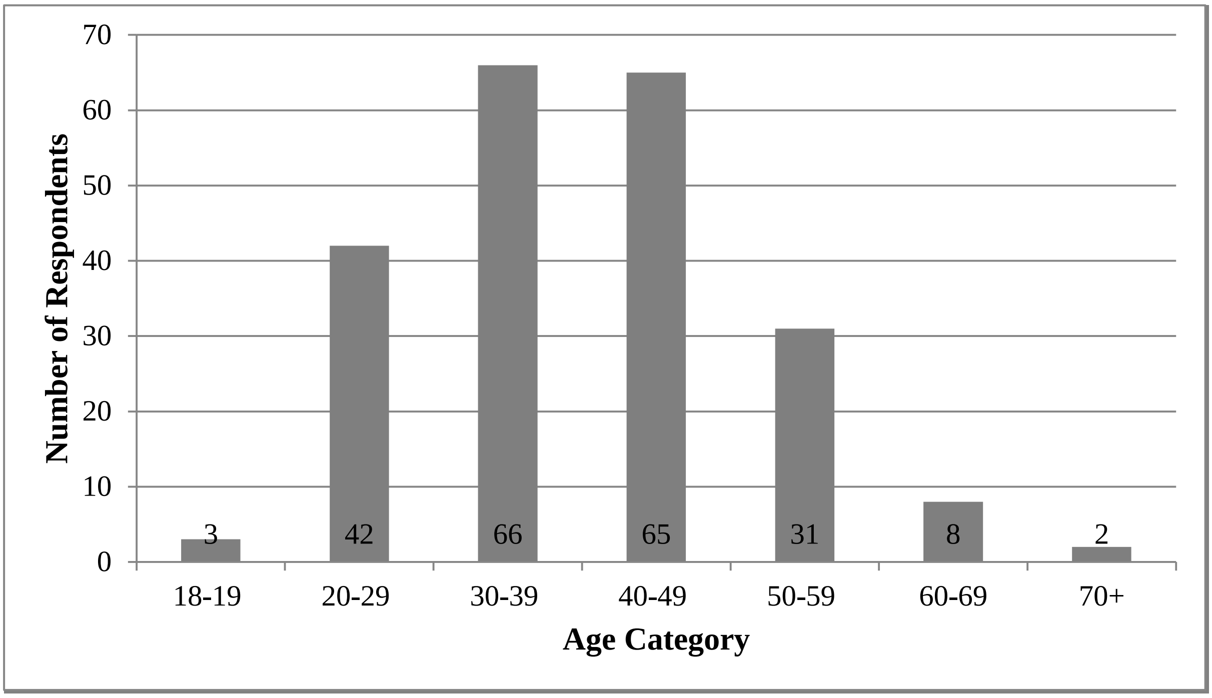

Figure 5.1. Frequency Distribution of Age Groups among the Study Participants (*N* = 117)

In terms of population group, the majority of the sample was Caucasian (82.3%). Individuals of Coloured (7.3%), African (6%), and Asian/Indian (1.4%) ethnic origin were also among the respondents. A further three participants (1.4%) reported belonging to a group labelled, *other*, while another four runners (1.8%) did not indicate their population group.

Aside from demographic information, data were collected pertaining to running experience, performance level, and the frequency of logbook keeping. The running experience levels of the current participants are depicted in Figure 5.2.

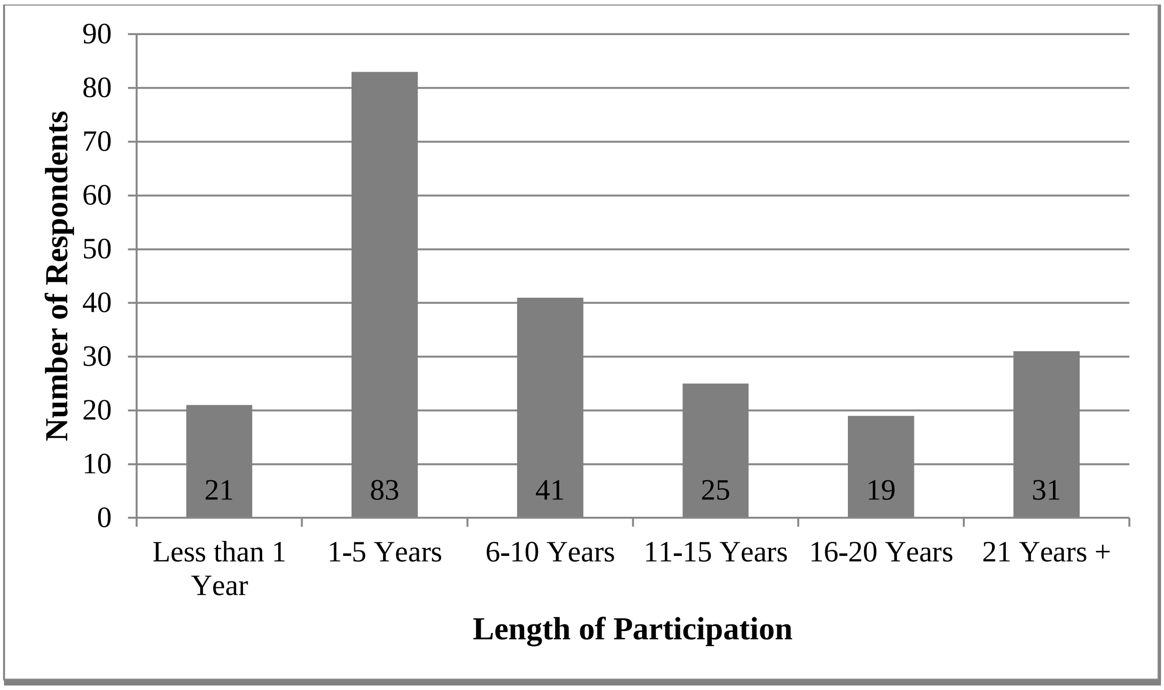

Figure 5.2. Frequency Distribution of Running Experience Levels (*N* = 220)

As observed, most of the respondents were fairly experienced runners. It was found that 199 members of the research sample (90.5%) had taken part in the sport for at least one year, while 116 respondents (52.7%) had been running for a minimum of five years. More than one-third of the study group (34.1%) had participated in the sport for longer than a decade, while 31 individuals (14.1%) had been runners for more than 20 years. In contrast, only 21 respondents (9.5%) indicated that they had been running for a period of less than 12 months.

Figure 5.3 pictures the self-described performance levels of the current group of runners.

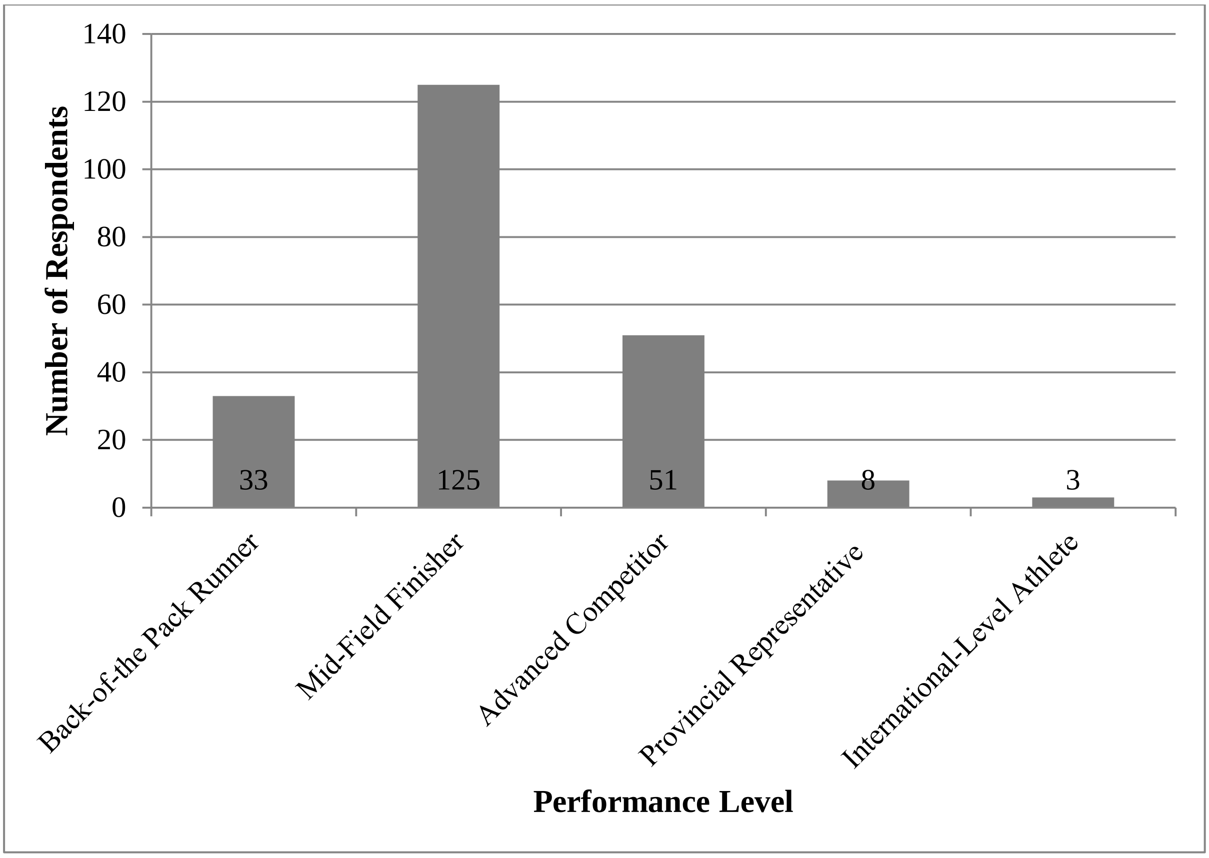

Figure 5.3. Frequency Distribution of Self-Described Performance Levels (*N* = 220)

As shown, the study participants were predominantly of average running ability, as expected. A total of 125 runners (56.8%) reported finishing within the mid-section of the field in most events they entered. A further 33 individuals (15%) described themselves as back-of-the-pack runners. A total of 51 respondents (23.2%) reported being advanced competitors, finishing within the top 10 to 25 percent of the field in races. The remaining 11 study participants (5%) could be classified as semi-elite or elite athletes. Eight members of this group (3.6%) reported having represented their respective province in recent national competition. A further three individuals (1.4%) indicated that they had recently competed at international level.

Participant responses to the query concerning the practice of logbook keeping showed that most of the respondents (68.6%) always or usually kept a daily record of their running activity. A total of 109 participants (49.5%) selected the *always* response option to this question, while a further 42 (19.1%) chose the *usually* option. Only 29 runners (13.2%) indicated that they never recorded training data, while another 40 respondents (18.2%) reported doing so on an occasional basis. The issue concerning logbook-keeping practices has relevance for the reliability of self-reports relating to training habits, and overuse injury and URTI history.

Data were also elicited in relation to the study group's participation in other modes of aerobic exercise. It was evident that a large number of respondents participated in at least one other form of endurance training apart from distance running. A total of 166 participants (75.4%) reported engaging in activities such as cycling, swimming, rowing, canoeing, and spinning on a regular basis. The weekly duration of participation in these additional pursuits ranged from less than an hour (18.2%) to seven hours or more (6.8%). The balance of this group (50.4%) reported devoting between one and six hours per week to the above-mentioned pastimes.

Respondents also provided information concerning their incidence of allergies involving the upper respiratory tract, such as hay fever. In this regard, 144 participants (65.4%) indicated that they did not suffer from an allergic disorder of this type. However, 66 runners (30%) responded in the affirmative to this query, while 10 others (4.5%) reported being uncertain of their allergy status. Knowledge of the occurrence of allergic conditions among the study group may have relevance for the reliability of self-reported URTI episodes. For instance, it is plausible that some individuals may mistake hay fever symptoms for those of a URTI.

Descriptive Statistics: Personality and Motivation

Descriptive statistics, including means, medians, standard deviations (SD), and minimum and maximum scores, were computed for each of the personality and motivation variables among the present sample. These values are shown in Table 5.1. Cronbach *alpha* coefficients are also reported.

Perfectionism and Type A Behaviour

A total of 23 study participants did not complete one or more items on the Multidimensional Perfectionism Scale (MPS) (Frost et al., 1990). Also, 20 respondents omitted to answer one or more items on the Type A Rating Scale Inventory (TASRI) (Blumenthal et al., 1985). In order to be able to include these participants in the statistical analyses, the technique of item mean substitution was used. This procedure entailed replacing the missing item values with the computed sample mean for the respective items.

Table 5.1

Descriptive Statistics for Personality and Motivation Variables (N = 220)

Variable	**Mean**	**SE**	**Median**	**SD**	**Min**	**Max**	***alpha***
Perfectionistic Strivings	24.1	0.31	24.0	4.6	9.0	35.0	0.79
Perfectionistic Concerns	30.7	0.58	30.0	8.7	13.0	54.0	0.89
Parental Perceptions	20.0	0.40	20.0	5.9	9.0	45.0	0.85
Type A Behaviour	116.2	1.26	115.0	18.7	73.0	179.0	0.88
Ego Goal Orientation	16.8	0.37	17.0	5.5	6.0	29.0	0.91
Task Goal Orientation	27.1	0.23	28.0	3.4	6.0	30.0	0.89

Note. SE: Standard error
SD: Standard deviation

Table 5.1 shows that the current group obtained a mean score of 24.1 (median = 24.0, SD = 4.6) on the seven-item MPS Personal Standards subscale, which was used to assess perfectionistic strivings. This implied that respondents, in general, demonstrated moderate-to-high levels of achievement striving, or adaptive perfectionism. Scores on this five-point scale ranged from 9.0 to 35.0. A Cronbach *alpha* coefficient of 0.79 was computed for this measure, suggesting an acceptable level of internal consistency reliability.

The sample mean for the combined Concern over Mistakes and Doubts about Actions subscales of the MPS was 30.7 (median = 30.0, SD = 8.7). This figure indicated that the average study participant displayed low-to-moderate levels of perfectionistic concerns, or self-critical perfectionism. Observed scores for this variable ranged from 13.0 to 54.0. The combined 13-item measure was shown to have good internal consistency reliability (Cronbach's *alpha* = 0.89).

Participants recorded a mean score of 20.0 (median = 20.0, SD = 5.9) on the combined Parental Expectations and Parental Criticism subscales of the MPS, which was used to assess the parental perceptions variable. This result suggested that respondents were mostly inclined to disagree with statements implying that their parents imposed overly high standards of performance. Minimum and maximum scores for this scale were 9.0 and 45.0, respectively. A

Cronbach *alpha* coefficient of 0.85 was computed for the combined nine-item measure, which indicated a high level of internal consistency reliability.

As seen in Table 5.1, the study participants recorded a mean score of 116.2 (median = 115.0, SD = 18.7) on the 28-item TASRI (Blumenthal et al., 1985). This figure suggested that the typical respondent was marginally inclined to exhibit the Type A behaviour pattern. Observed scores for this seven-point measure ranged from 73.0 to 179.0. A total of 92 participants (41.8%) obtained a score of 120 or higher, which has been proposed as a cut-off score to identify Type A individuals (Fields et al., 1990). Persons scoring above this value have a 78% probability of being classified as 'Type A' in a structured interview assessment (Fields et al., 1990). The results of the current study indicated that a fairly large proportion of participants could be described as having the Type A behaviour pattern. A Cronbach *alpha* coefficient of 0.88 was obtained for the sample in the present study, indicating that the TASRI has good internal reliability.

Achievement Goal Orientations

It was found that eight respondents did not fully complete the 12-item Perception of Success Questionnaire (Roberts et al., 1998). Also, two participants failed to answer any items on the ego goal orientation subscale. The missing data problem was addressed by employing the method of item mean substitution, as described earlier.

The results of the descriptive analyses indicated that the average participant was more likely to endorse task versus ego goals in a sporting domain. As Table 5.1 shows, respondents obtained a mean score of 27.1 (median = 28.0, SD = 3.4) on the six-item task goal subscale. This finding implied that members of the current sample were quite strongly inclined to perceive success in terms of mastery or improvement. Scores for this five-point measure ranged from 6.0 to 30.0. A group mean of 16.8 (median = 17.0, SD = 5.5) was recorded for the six-item ego goal subscale. This suggested that participants, as a whole, reported a low-to-moderate tendency to adopt normative conceptions of competency. Observed minimum and maximum scores for this measure were 6.0 and 29.0, respectively. In the present study, Cronbach's *alphas* of 0.89 were obtained for the task goal measure and 0.91 for the ego goal subscale.

Descriptive Statistics: Running Addiction and Training Load

Descriptive statistics (central tendency and variability) were also computed for the running addiction and training load measures. These values are presented in Table 5.2. Where appropriate, Cronbach *alpha* coefficients are also reported.

Table 5.2

Descriptive Statistics for Running Addiction and Training Load Measures (N = 220)

Measured Variable	**Mean**	**SE**	**Median**	**SD**	**Min**	**Max**	***alpha***
Running Addiction	20.0	0.26	20.0	3.9	10.0	30.0	0.69
Training Volume (Km/Week)	48.6	1.15	45.0	17.1	25.0	95.0	~
Training Intensity (2 – 5)	2.9	0.03	2.9	0.4	2.0	4.2	~
Training Workload (Vol × Int)	140.1	3.72	133.9	55.2	50.0	312.14	~
Training Freq. (Days/Week)	4.3	0.09	4.5	1.3	1.0	10.0	~
Competition Freq. (Races/Year)	14.1	0.50	12.0	7.4	0.0	45.0	~
Underrecovery	27.8	0.39	28.0	5.8	15.0	49.0	0.81

Note. SE: Standard error
SD: Standard deviation
~ These variables were assessed using a checklist approach; therefore, internal consistency reliabilities are not meaningful

Running Addiction

It was found that one study participant did not answer any of the six items on the Exercise Addiction Inventory (Terry et al., 2004), while another respondent only partially completed this measure. Once more, the item mean calculated across respondents was substituted for each missing value.

As Table 5.2 demonstrates, the current sample recorded a mean score of 20.0 on the slightly modified version of the Exercise Addiction Inventory (median = 20.0, SD = 3.9). Scores for this five-point scale ranged from 10.0 to 30.0. The location of the group mean within the 13 to 23 range suggested that the average study participant displayed some symptoms of running addiction (Terry et al., 2004). A total of 37 runners (16.8%) obtained scores of 24 or higher, which placed them within the ‘at-risk’ category, as defined by Terry et al. (2004). Of this group, 20 were female (54%) and 17 were male (46%). Therefore, 21.3% of female and 13.8% of male respondents appeared to be susceptible to the disorder. The scores of a further 179 runners (81.4%) were situated within the ‘symptomatic’ range of 13 to 23. A total of 104 of these participants (58.1%) were male, and 72 (40.2%) were female. (Three of these respondents did not indicate their gender.) Only four runners (1.8%), comprising two men and two women, obtained scores of 12 or lower and thus appeared to ‘asymptomatic’ (Terry et al., 2004). A relatively low yet still acceptable *alpha* coefficient of 0.69 was computed for the measure. The distribution of running addiction scores according to risk category and gender is depicted in Figure 5.4.

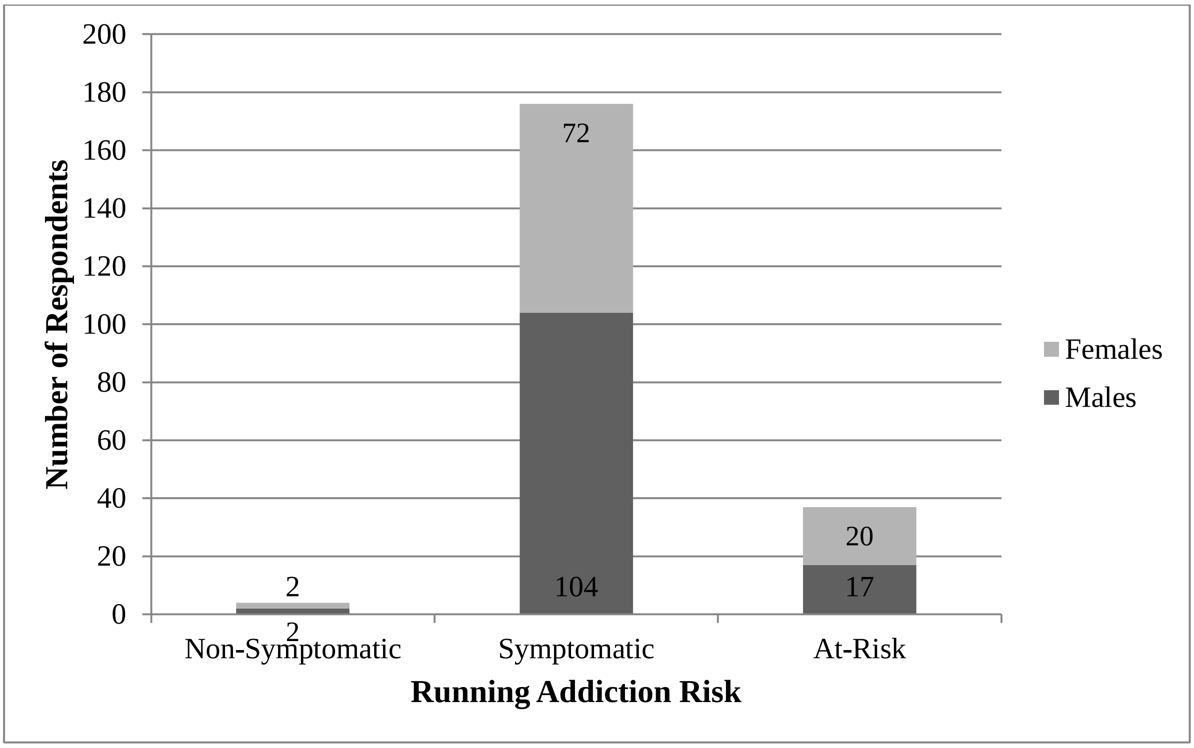

Figure 5.4. Frequency Distribution of Running Addiction Scores in Relation to Risk Category and Gender (N = 117)

Training Load

A total of three study participants provided no information for the training volume, frequency, or intensity measures for either heavy or light training periods. Another 10 runners provided only partial data for these variables. For example, six participants supplied training information for heavy training phases but incomplete or nil data for lighter training phases. The balance of this group omitted to furnish details for one or more training dimensions (i.e., volume, frequency, or intensity) for either heavy or light training cycles. Further to this, three participants skipped an item on the underrecovery measure. In all the above-mentioned cases, the respective sample mean was substituted for the missing values.

As seen in Table 5.2, an analysis of the training habits of the sample indicated that participants, in general, covered a total distance of 48.6 kilometres per week in training (median = 45, SD = 17.1). The lowest and highest reported weekly training volumes averaged across heavy and light training periods were 25 kilometres and 95 kilometres, respectively. A mean exertion rating of 2.9 (median = 2.9, SD = 0.4) was recorded for the training intensity measure. This implied that the average participant customarily trained at a relatively high level of effort, corresponding to about 70% – 80% of maximum heart rate. In terms of subjective ratings of perceived exertion, this level of intensity could be described as 'somewhat hard'. It was also found that the typical respondent engaged in an average of 4.3 training sessions per week (median = 4.5, SD = 1.3).

Self-reported competition behaviour indicated that the typical respondent participated in approximately 14 races of at least four kilometres in distance each year (*M* = 14.1, median = 12.0, SD = 7.4). An analysis of competition habits according to race-distance category revealed that the most popular events were races of four kilometres to 10 kilometres, and 15 kilometres to 21.1 kilometres. The current group reported participating in approximately five races belonging to each of these race-distance categories every year.

A mean score of 27.8 (median = 28.0, SD = 5.8) was recorded for the 10-item underrecovery measure, with observed values ranging from 15.0 to 49.0. This implied that participants, on average, demonstrated a low-to-intermediate level of underrecovery tendencies. In general, therefore, these runners were slightly more disinclined than inclined to disregard symptoms of physical strain that could indicate inadequate recovery from previous hard efforts. A Cronbach *alpha* coefficient of 0.81 was computed for this scale, indicating a sufficiently-high level of internal consistency reliability.

Descriptive Statistics: URTIs and Running Injuries

Descriptive statistics (central tendency and variability) were also computed for all URTI and running injury measures among the research sample.

Upper Respiratory Tract Infections

It was found that all respondents reporting URTI occurrences in the previous three months provided the necessary data for the dimensions of illness severity, duration, and URTI-related training stoppages. However, two study participants failed to provide any information for this variable. Since these individuals had complied with all the other survey requirements, the missing information was interpreted to indicate that no infectious episodes had occurred.

An analysis of self-reported URTIs revealed that 104 runners (47%) had experienced one or more bouts of the common cold, influenza, coughing, or sore throat during the preceding three months. Further, 87 participants, representing 39% of all respondents and 84% of symptomatic runners, reported experiencing URTI-related training disruptions during this time. Descriptive statistics for the URTI measures appear in Table 5.3. Where appropriate, Cronbach *alpha* coefficients are also reported.

As Table 5.3 shows, individuals reporting URTI occurrences had typically experienced about one infectious episode during the preceding three months (*M* = 1.3, median = 1.0, SD = 0.6). The mean severity rating assigned to these URTI events was 1.9 (median = 2.0, SD = 0.4). This score implied that infections had mainly been of a moderate nature and had restricted daily routines and activities to a modest degree. The average duration of illness episodes among this group was in the order of six days (*M* = 6.2, median = 6.5, SD = 2.7), while URTI-related training disruptions had lasted around seven days (*M* = 6.9, median = 4.0, SD = 7.3). This figure was found to be slightly higher when participants reporting URTI-induced training cessations were analysed separately (*M* = 8.2, median = 4.0, SD = 7.3).

The study participants recorded a mean score of 8.6 (median = 8.0, SD = 4.2) on the four-item, seven-point URTI history scale. Scores on this measure ranged from 4.0 to 24.0. The relatively low mean score suggested that, for the average respondent, URTIs, particularly of a restricting nature, had rarely been experienced during the preceding 12 months. A Cronbach *alpha* coefficient of 0.89 was computed for this scale, suggesting an adequate level of internal consistency reliability.

Table 5.3

Descriptive Statistics for URTI Measures

Measured Variable	***n***	**Mean**	**SE**	**Median**	**SD**	**Min**	**Max**	***alpha***
URTI Number	104	1.3	0.06	1.0	0.6	1.0	3.0	~
URTI Severity (1 – 3)	104	1.9	0.07	2.0	0.4	1.0	3.0	~
URTI Duration (Days)	104	6.2	0.26	6.5	2.7	2.5	10.5	~
URTI Time Loss (Days)	104	6.9	0.72	4.0	7.3	0.0	32.0	~
URTI Time Loss (Days)*	87	8.2	0.78	4.0	7.3	4.0	32.0	~
URTI History	220	8.6	0.28	8.0	4.2	4.0	24.0	0.89

Note. SE: Standard error
SD: Standard deviation
*Participants reporting URTI-related training stoppages
~ These variables were assessed using a checklist approach; therefore, internal consistency reliabilities are not meaningful.

Running Injuries

A total of 12 participants reporting injury occurrences omitted to provide data for pain duration, severity, and/or pain-related training stoppages for some or all reported injuries. If partial information was available for a specific dimension, then this information was utilized in the inferential statistical analyses. For example, if ankle and knee pain were reported, but information for knee pain duration was not provided, then the injury duration index was calculated on the basis of ankle pain only. However, if no data had been provided for a specific dimension, then the relevant sample mean was substituted for the missing value.

An analysis of self-reported running injuries indicated that 199 study participants (90%) had experienced running-related pain in one or more anatomical sites during the preceding three months. Also, 126 individuals – representing 57% of the research sample and 63% of injured runners – reported pain-induced training stoppages during this time.

Descriptive statistics for the injury measures appear in Table 5.4. Runners failing to provide any data for the respective overuse injury dimension (i.e., severity, duration, time loss) were not included in this analysis. Cronbach *alpha* coefficients are also reported, as appropriate.

Table 5.4

Descriptive Statistics for Running Injury Measures

Measured Variable	***n***	**Mean**	**SE**	**Median**	**SD**	**Min**	**Max**	***alpha***
Injury Number	199	2.6	0.11	2.0	1.5	1.0	8.0	~
Injury Severity (1 – 4)	198	2.2	0.06	2.0	0.9	1.0	4.0	~
Injury Duration (Days)	196	12.2	0.70	7.5	9.8	4.0	32.0	~
Injury Time Loss (Days)	190	11.6	1.06	4.0	14.7	0.0	64.0	~
Injury Time Loss (Days)*	126	17.4	1.33	11.5	14.9	4.0	64.0	~
Injury History	220	11.3	0.31	11.0	4.6	4.0	24.0	0.62

Note. SE: Standard error
SD: Standard deviation
*Participants reporting injury-related training stoppages
~ These variables were assessed using a checklist approach; therefore, internal consistency reliabilities are not meaningful.

As Table 5.4 shows, the typical injured runner had experienced between two and three different injuries in the previous three months (*M* = 2.6, median = 2.0, SD = 1.5). The mean severity rating assigned to these injuries was 2.2 (median = 2.0, SD = 0.9). This score indicated that injured participants had generally felt pain during running, but running capacity had not been affected. The average duration of injury occurrences was approximately 12 days (*M* = 12.2, median = 7.5, SD = 9.8), while reported pain-related training stoppages was also in the region of 12 days (*M* = 11.6, median = 4.0, SD = 14.7). However, this figure was significantly higher among individuals reporting injury-induced training disruptions (*M* = 17.4, median = 11.5, SD = 14.9).

The sample recorded a mean score of 11.3 (median = 11.0, SD = 4.6) on the four-item seven-point injury history scale. Scores on this measure ranged from 4.0 to 24.0. This figure implied that participants had only occasionally experienced running injuries, especially of a disruptive kind, over the previous 12 months. A relatively low Cronbach *alpha* coefficient of 0.62 was computed for this scale.

When self-reported running-related pain occurrences were examined on the basis of anatomical site, it was found that the knee appeared to be most vulnerable to injury. The prevalence of injury episodes in relation to bodily location is displayed in Figure 5.5.

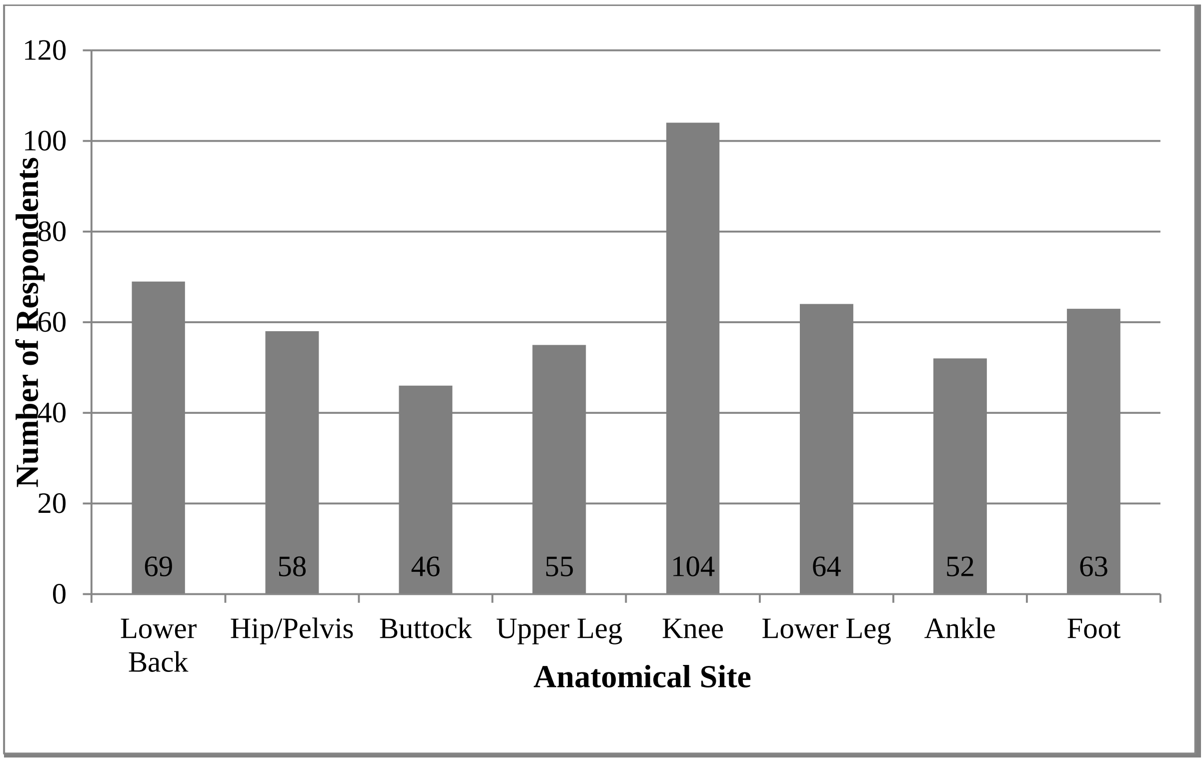

Figure 5.5. Prevalence of Self-Reported Injuries in Relation to Anatomical Site (*n* = 199)

As depicted, 104 study participants (47%), corresponding to 52% of all injured runners, reported having experienced knee pain in the previous three months. The occurrence of other self-reported injuries exhibited minimal variation in terms of anatomical region. The second most common injury site was the lower back with 69 participants, representing 31% of the sample and 35% of all injured runners, reporting prior pain in this location. The least common injury site was the buttock with 21% of the sample and 23% of injured runners (*n* = 46) noting recent pain in this area.

Descriptive statistics (percentages and means) for the different injury sites are provided in Table 5.5.

Table 5.5

Descriptive Statistics in Relation to Anatomical Site for Self-Reported Injury Occurrences

Injury Site	***n***	**% of Sample (*N* = 220)**	**% of Injured (*n* = 199)**	**Mean Severity (1 – 4)**	**Mean Duration (Days)**	**Mean Time Loss (Days)***
Lower Back	69	31%	35%	1.8	10.3	9.2
Hip/Pelvis	58	26%	29%	2.2	11.9	10.7
Buttock	46	21%	23%	2.0	12.1	8.2
Upper Leg	55	25%	28%	1.8	8.0	4.6
Knee	104	47%	52%	2.4	12.2	12.2
Lower Leg	64	29%	32%	2.4	11.0	13.0
Ankle	52	24%	26%	2.1	11.6	7.0
Foot	63	29%	32%	2.1	12.5	11.7

As observed, an assessment of the different injury dimensions in relation to anatomical location indicated that self-reported lower leg and knee pain had been the most incapacitating disorders among the sample (M = 2.4). Lower back and upper leg injuries appeared to have been the least debilitating complaints (M = 1.8). It was found that foot, knee, and buttock problems had been the most persistent of all injury problems, lasting for approximately 12 days in each case. Upper leg pain had reportedly lasted for the shortest period of time, specifically for an average of eight days. With regard to self-reported injury-related training disruptions, lower leg disorders seemed to have caused the longest training cessations (M = 13.0 days). Upper leg injuries had led to the shortest training stoppages (M = 4.6 days).

Normality of Data Distribution

In addition to computing descriptive statistics relating to central tendency and variability, an inferential test for normality was performed for each of the observed and latent study variables. The Kolmogorov-Smirnov test, which is used in the case of continuous distributions and when $N \geq 50$ (Rovai, Baker & Ponton, 2014), was utilized for this purpose. The results are reported in Table 5.6.

Table 5.6

Kolmogorov-Smirnov[a] Test for Normality for Measured and Latent Study Variables

Variable	**Statistic**	***df***	***p***
Perfectionistic Concerns	0.086	220	0.000
Perfectionistic Strivings	0.084	220	0.001
Parental Perceptions	0.084	220	0.001
Type A Behaviour Pattern	0.046	220	0.200
Ego Goal Orientation	0.193	220	0.000
Task Goal Orientation	0.064	220	0.027
Running Addiction	0.068	220	0.015
Training Workload	0.060	220	0.053
Training Frequency	0.107	220	0.000
Competition Frequency	0.127	220	0.000
Underrecovery	0.064	220	0.029
Injury History	0.102	220	0.000
Injury Number	0.209	220	0.000
Injury Severity	0.116	220	0.000
Injury Duration	0.219	220	0.000
Injury Time Loss	0.230	220	0.000
URTI History	0.152	220	0.000
URTI Number	0.318	220	0.000
URTI Severity	0.326	220	0.000
URTI Duration	0.318	220	0.000
URTI Time Loss	0.320	220	0.000
Perfectionism	0.065	220	0.025
Running Load	0.064	220	0.030
Running Injuries	0.112	220	0.000
URTIs	0.176	220	0.000

Note. [a] Lilliefors significance correction
df: Degrees of freedom
p: Probability value

As shown, only Type A behaviour pattern and training workload demonstrated normal distributions (i.e., $p > 0.05$). Findings with respect to the normality of the study data have relevance for decision-making in the context of both correlational and SEM analyses. For example, when assessing relationships among variables, the distribution of scores influences the selection of the appropriate test of association (Fife-Schaw, 1998). Also, in SEM, nonnormal data distributions may inflate the chi-square test statistic thus indirectly affecting decisions concerning the adequacy of the proposed model (Klem, 2000).

Correlational Statistical Analysis

The simple, bivariate relationships among perfectionism, Type A behaviour, task goal orientation, ego goal orientation, running addiction, training load, URTIs, and running injuries were also assessed. In this analysis, perfectionism, training load, URTIs, and running injuries were constituted by summing the scores obtained for each variable's sub-dimensions. Since most of these variables were not normally distributed, Spearman's *rho*, which is the only non-parametric product-moment correlation (Hammond, 1995), was used to analyse these associations. The results are reported in Table 5.7.

As observed, several statistically significant correlations were observed among the key study variables. It was found that running addiction was significantly related to perfectionism (r = 0.20, p = 0.003 two-tailed), Type A behaviour (r = 0.20, p = 0.002 two-tailed), task goal orientation (r = 0.23, p = 0.001 two-tailed), training load (r = 0.32, p = 0.000 two-tailed), and running injuries (r = 0.16, p = 0.017 two-tailed). In addition, training load was significantly related to Type A behaviour (r = 0.13, p = 0.046) and task goal orientation (r = 0.19, p = 0.005 two-tailed). Further significant correlations were observed between Type A behaviour and perfectionism (r = 0.15, p = 0.027 two-tailed), between perfectionism and ego goal orientation (r = 0.25, p = 0.000 two-tailed), and between task and ego goal orientation (r = 0.18, p = 0.008 two-tailed).

Table 5.7

Non-Parametric Correlation Coefficients (Spearman's rho) Representing Bidirectional Relationships among Key Study Variables (N = 220)

Variable	TA	TG	EG	RA	PF	TL	RI	UR
Type A Behaviour (TA)	1.00							
Task Goal Orientation (TG)	0.11	1.00						
Ego Goal Orientation (EG)	-0.00	0.18**	1.00					
Running Addiction (RA)	0.20**	0.23**	0.09	1.00				
Perfectionism (PF)	0.15*	-0.03	0.25**	0.20**	1.00			
Training Load (TL)	0.13*	0.19**	0.12	0.32**	0.07	1.00		
Running Injuries (RI)	0.06	0.06	-0.04	0.16*	0.03	-0.02	1.00	
URTIs (UR)	-0.02	-0.07	0.07	0.02	0.08	-0.06	0.07	1.00

Note. ** Significant at the 0.01 level (2-tailed)
* Significant at the 0.05 level (2-tailed)

Structural Equation Modelling Analysis

As noted in the previous chapter, structural equation modelling is typically conducted in three broad stages (Marsh, 2007; Klem, 2000). The first of these phases, model specification, was discussed in some depth in the previous chapter. The following two stages, namely parameter estimation and model fit evaluation, respectively, are described in this section with reference to the hypothesized structural equation model.

Parameter Estimation

In SEM terminology, a 'parameter' is defined as "a constant that measures the magnitude of the relationship between variables" (Klem, 2000, p. 256). 'Parameter estimation', in turn, is "the generation of a set of model parameters in relation to a particular estimation procedure" (Marsh, 2007, p. 775). The predominant estimation method employed in SEM is maximum likelihood (ML) estimation (Anderson & Gerbing, 1998; Klem, 2000; Marsh, 2007). As noted in the previous chapter, this estimation procedure assumes multivariate normality, a requirement that is rarely met in sport and exercise psychology research (Marsh, 2007). However, ML parameter estimates are generally robust against most violations of multivariate normality (Anderson & Gerbing, 1988; Klem, 2000). Multivariate normality requires that variables are both univariate and bivariate normal (Rovai et al., 2014). This means that each variable and all combinations of variables should be normally distributed (Rovai et al., 2014).

There are several kinds of parameters in SEM (Klem, 2000). These include coefficients that represent hypothesized directional and nondirectional relations in the model. Directional relations refer to the effects of one variable on another. Parameters that measure these effects are analogous to the coefficients from a multiple regression analysis (βs or betas) (Klem, 2000). In the measurement submodel, the path coefficients or regression weights that represent the effects of factors on their respective indicators are called factor loadings (Byrne, 2001; Klem, 2000). Further parameters include the variances and covariances among unmeasured independent variables, and among errors in measured variables (Klem, 2000). The error associated with measured variables represents random measurement error (Byrne, 2001). Error also refers to the effects of variables omitted from the model (Klem, 2000).

Parameter Estimation: Measurement Model

The nonstandardized and standardized factor loadings representing the pattern of relations between each latent variable and its indicators are reported in Tables 5.8 and 5.9. The nonstandardized regression weights express relations between variables in terms of their respective scales of measurement. Conversely, the standardized coefficients are transformed coefficients that enable the factor loadings to be directly compared (Biddle & Marlin, 1987). In the former analysis, the statistical program automatically fixed one of the indicator paths of each factor to 1.00 (Byrne, 2001).

As seen in Table 5.8, each of the measured variables loaded significantly on the factors they were designed to represent. To reiterate, these factors were perfectionism, training load, running injuries, and URTIs. Table 5.9 demonstrates that the magnitude of these factor loadings ranged from 0.57 to 0.87 for perfectionism, 0.19 to 0.76 for training load, 0.42 to

0.76 for running injuries, and from 0.55 to 0.94 for URTIs. The standardized regression coefficients show that the leading indicators of perfectionism and training load were perfectionistic concerns (0.87) and training workload (0.76), respectively. Injury time loss (0.76) and URTI severity (0.94) served as the best measures of the running injury and URTI factors, respectively.

Table 5.8

Nonstandardized Factor Loadings Representing the Effects of the Unmeasured Variables on their Indicators

Factor (Unmeasured Variable)	**Path**	**Indicator (Measured Variable)**	**Estimate**	**SE**	**CR**	***p***
Perfectionism	--->	Parental Perceptions	1.00			
Perfectionism	--->	Perfectionistic Concerns	2.25	0.35	6.50	0.000
Perfectionism	--->	Perfectionistic Strivings	0.87	0.13	6.86	0.000
Training Load	--->	Training Workload	1.00			
Training Load	--->	Training Frequency	0.02	0.00	5.72	0.000
Training Load	--->	Competition Frequency	0.07	0.02	4.34	0.000
Training Load	--->	Underrecovery	0.03	0.01	2.31	0.021
Running Injuries	--->	Injury Severity	1.00			
Running Injuries	--->	Injury Duration	6.81	1.17	5.83	0.000
Running Injuries	--->	Injury Number	1.02	0.19	5.27	0.000
Running Injuries	--->	Injury History	4.67	0.59	7.90	0.000
Running Injuries	--->	Injury Time Loss	15.51	1.90	8.19	0.000
URTIs	--->	URTI Severity	0.43	0.05	9.17	0.000
URTIs	--->	URTI Duration	1.41	0.16	9.05	0.000
URTIs	--->	URTI Number	0.29	0.03	8.84	0.000
URTIs	--->	URTI History	1.00			
URTIs	--->	URTI Time Loss	1.98	0.24	8.23	0.000

Note. SE: Standard error
CR: Critical ratio (nonstandardized estimate/standard error)
p: Probability value

Table 5.9

Standardized Factor Loadings Representing the Effects of the Unmeasured Variables on their Indicators

Factor (Unmeasured Variable)	**Path**	**Indicator (Measured Variable)**	**Estimate**
Perfectionism	--->	Parental Perceptions	0.57**
Perfectionism	--->	Perfectionistic Concerns	0.87**
Perfectionism	--->	Perfectionistic Strivings	0.63**
Training Load	--->	Training Workload	0.76**
Training Load	--->	Training Frequency	0.66**
Training Load	--->	Competition Frequency	0.38**
Training Load	--->	Underrecovery	0.19*
Running Injuries	--->	Injury Severity	0.66**
Running Injuries	--->	Injury Duration	0.47**
Running Injuries	--->	Injury Number	0.42**
Running Injuries	--->	Injury History	0.70**
Running Injuries	--->	Injury Time Loss	0.76**
URTIs	--->	URTI Severity	0.94**
URTIs	--->	URTI Duration	0.91**
URTIs	--->	URTI Number	0.86**
URTIs	--->	URTI History	0.55**
URTIs	--->	URTI Time Loss	0.76**

Note. ** Significant at the 0.01 level (2-tailed)
* Significant at the 0.05 level (2-tailed)

Parameter Estimation: Structural Model

Tables 5.10 and 5.11 display the computed nonstandardized and standardized regression weights representing hypothesized directional effects in the structural submodel.

Table 5.10

Nonstandardized Regression Weights Representing Hypothesized Direct Effects in the Structural Submodel

Predictor Variable	**Path**	**Dependent Variable**	**Estimate**	**SE**	**CR**	***p***
Perfectionism	--->	Running Addiction	0.26	0.09	2.90	0.004
Type A Behaviour	--->	Running Addiction	0.03	0.01	2.40	0.016
Ego Goal Orientation	--->	Running Addiction	0.01	0.05	0.26	0.795
Perfectionism	--->	Training Load	-0.89	1.11	-0.80	0.422
Type A Behaviour	--->	Training Load	0.08	0.17	0.46	0.648
Ego Goal Orientation	--->	Training Load	0.68	0.59	1.16	0.246
Running Addiction	--->	Training Load	4.29	0.90	4.76	0.000
Task Goal Orientation	--->	Training Load	1.20	0.96	1.24	0.213
Training Load	--->	Running Injuries	-0.00	0.00	-1.12	0.261
Running Addiction	--->	Running Injuries	0.05	0.01	3.21	0.001
Training Load	--->	URTIs	-0.00	0.00	-0.33	0.738
Running Addiction	--->	URTIs	-0.00	0.05	-0.04	0.972

Note. SE: Standard error
CR: Critical ratio (nonstandardized estimate/standard error)
p: Probability value

Tables 5.10 and 5.11 indicate that several directional relationships in the specified path model were statistically significant at the 0.05 probability level or better. In support of the research hypotheses, it was found that running addiction was predicted by perfectionism (0.26, SE = 0.09, CR = 2.90) and Type A behaviour (0.03, SE = 0.01, CR = 2.40). An inspection of the standardized regression weights provided in Table 5.11 reveals that the effect of perfectionism on running addiction (0.22) was stronger than the impact of Type A behaviour on this variable (0.16). As expected, running addiction had a direct positive effect on both training load (4.29, SE = 0.9, CR = 4.76) and running injuries (0.05, SE = 0.01, CR = 3.21).

Contrary to predictions, a number of relationships in the hypothesized model were not statistically significant. It was found that perfectionism, Type A behaviour, and achievement goal orientations did not directly influence training load. Also, ego goal orientation did not have a significant impact on running addiction. Further, training load did not affect running injuries, while neither running addiction nor training load predicted URTIs.

Table 5.11

Standardized Regression Weights Representing Hypothesized Direct Effects in the Structural Submodel

Predictor Variable	**Path**	**Dependent Variable**	**Estimate**
Perfectionism	--->	Running Addiction	0.22**
Type A Behaviour	--->	Running Addiction	0.16*
Ego Goal Orientation	--->	Running Addiction	0.02
Perfectionism	--->	Training Load	-0.07
Type A Behaviour	--->	Training Load	0.04
Ego Goal Orientation	--->	Training Load	0.09
Running Addiction	--->	Training Load	0.40**
Task Goal Orientation	--->	Training Load	0.10
Training Load	--->	Running Injuries	-0.11
Running Addiction	--->	Running Injuries	0.28**
Training Load	--->	URTIs	-0.03
Running Addiction	--->	URTIs	-0.00

Note. ** Significant at the 0.01 level (2-tailed)
* Significant at the 0.05 level (2-tailed)

The covariances reflecting hypothesized bivariate correlations in the specified model are provided in Tables 5.12 and 5.13. As Tables 5.12 and 5.13 depict, several of the hypothesized bidirectional relationships in the specified model were statistically significant. It was found that perfectionism was positively associated with Type A behaviour (11.03, SE = 4.92, CR = 2.24), while task and ego goal orientation were also positively related (4.17, SE = 1.29, CR = 3.24). Although the predicted negative correlation between perfectionism and task goal orientation failed to reach statistical significance at the 0.05 level, it was found to be significant at the 0.10 level (-1.61, SE = 0.85, CR = -1.89). Table 5.13 indicates that the magnitude of these associations was 0.18 for the perfectionism–Type A relationship, 0.22 for the task goal–ego goal correlation, and -0.14 for the perfectionism–task goal relation.

Table 5.12

Covariances Representing Hypothesized Bivariate Relationships in the Specified Model

Variable		Variable	Estimate	SE	CR	*p*
Perfectionism	<-->	Type A Behaviour	11.03	4.92	2.24	0.025
Task Goal Orientation	<-->	Ego Goal Orientation	4.17	1.29	3.24	0.001
Task Goal Orientation	<-->	Perfectionism	-1.61	0.85	-1.89	0.058

Note. SE: Standard error
CR: Critical ratio (nonstandardized estimate/standard error)
p: Probability value

Table 5.13

Correlation Coefficients Representing Hypothesized Bivariate Relationships in the Specified Model

Exogenous Variable		Exogenous Variable	Estimate
Perfectionism	<-->	Type A Behaviour	0.18*
Task Goal Orientation	<-->	Ego Goal Orientation	0.22**
Task Goal Orientation	<-->	Perfectionism	-0.14

Note. ** Significant at the 0.01 level (2-tailed)
* Significant at the 0.05 level (2-tailed)

Parameter Estimation: Variances

The squared multiple correlation coefficients for the endogenous variables in the specified model were also obtained. These coefficients are reported in Tables 5.14 and 5.15. The displayed values reflect the proportion of variance in the outcome or explained variables that are accounted for by the predictor or explanatory variables (Biddle & Marlin, 1987). The estimates provided in Table 5.14 represent the amount of variance in each measured variable or indicator that is explained by its corresponding latent variable or factor. The estimates provided in Table 5.15 represent the amount of variance in running addiction, training load, running injuries, and URTIs that is explained by their respective predictor variables.

Table 5.14

Squared Multiple Correlation Coefficients Relating to the Effects of Factors on their Corresponding Indicators

Indicator/Measured Variable	**Factor/Unmeasured Variable**	**Estimate**
Perfectionistic Strivings	Perfectionism	0.40
Perfectionistic Concerns	Perfectionism	0.76
Parental Perceptions	Perfectionism	0.32
Underrecovery	Training Load	0.04
Competition Frequency	Training Load	0.14
Training Frequency	Training Load	0.43
Training Workload	Training Load	0.57
Injury Number	Running Injuries	0.18
Injury Duration	Running Injuries	0.22
Injury Severity	Running Injuries	0.44
Injury History	Running Injuries	0.48
Injury Time Loss	Running Injuries	0.58
URTI Number	URTIs	0.75
URTI Duration	URTIs	0.83
URTI Severity	URTIs	0.88
URTI History	URTIs	0.30
URTI Time Loss	URTIs	0.57

Table 5.15

Squared Multiple Correlation Coefficients Relating to Running Addiction, Training Load, Running Injuries, and URTIs

Dependent Variable	**Estimate**
Running Addiction	0.09
Training Load	0.18
Running Injuries	0.07
URTIs	0.00

As Table 5.14 illustrates, perfectionism accounted for between 32% and 76% of the variance in its corresponding indicators, while training load explained 4% to 57% of the variance in its respective indicators. It was found that the running injury factor accounted for 18% to 58% of the variability in its corresponding observed variables, while the URTI variable explained 30% to 88% of the variability in its associated indicators. The proportion of unexplained variance in these variables is referred to as unique variance (Hoyle, 2012).

As shown in Table 5.15, the hypothesized model explained 9% of the variance in running addiction, 18% of the variance in training load, 7% of the variance in running injuries, and a negligible amount of the variance in URTIs.

Model Fit Assessment

Following estimation of the model parameters, the issue concerning the adequacy of the hypothesized model or its degree of correspondence to the data set was addressed. An evaluation of model adequacy primarily entails an assessment of the overall fit of the model to the observed data (Fabrigar & Wegener, 2014). The process of assessing model fit typically constitutes an inspection of various statistics and fit indices (Whittaker, 2012).

One of the most common statistical tests used to evaluate a model's degree of fit to the study data is the chi-square test (Fabrigar & Wegener, 2014; Klem, 2000; Marsh, 2007). The chi square test provides an estimate of the size of the differences between the implied and observed correlation matrices (Klem, 2000). In order for a model to be 'confirmed' or accepted, the chi-square statistic should be small and nonsignificant, which indicates that the model is largely consistent with the sample data (Biddle & Marlin, 1987; Klem, 2000). In other words, the significance test actually tests whether the model does *not* provide an adequate explanation of the empirical data. A high probability value signifies an increased likelihood that observed discrepancies between the hypothesized model and data set are chance occurrences (Klem, 2000).

It has been claimed, however, that the chi-square test is generally an unsatisfactory measure of model fit (Fabrigar & Wegener, 2014; Klem, 2000; Marsh, 2007). One of the reasons for this is that the chi-square statistic is sensitive both to multivariate nonnormality and sample size (Klem, 2000). For instance, nonnormality may inflate the chi-square value (Klem, 2000).

Also, for sufficiently large samples, the statistic may be significant despite relatively small discrepancies between the model and data. Conversely, for sufficiently small samples, the chi-square value may be nonsignificant in spite of fairly large discrepancies between the implied and observed data sets (Klem, 2000). In essence, therefore, the chi-square test may lead to the rejection or acceptance of a model primarily on the basis of sample size (Marsh, 2007).

In view of the limitations of the chi-square test, a number of supplementary fit indices have been proposed for the purpose of evaluating a model's adequacy (Fabrigar & Wegener, 2014; Klem, 2000; Marsh, 2007). These include the comparative fit index (CFI), the relative noncentrality index (RNI), the Tucker-Lewis index (TLI), the root mean square error of approximation (RMSEA), and the root mean square residual (RMR), among several others. These alternative measures are often referred to as descriptive fit indices as they do not involve formal hypothesis testing but are attempts to measure the extent to which the model fits the data (Fabrigar & Wegener, 2014). There is a lack of consensus among researchers concerning the issue of which goodness-of-fit indices are optimal (Klem, 2000). A perusal of the literature suggests that goodness-of-fit decisions in SEM studies are generally based on a combination of indices. This approach corresponds with the advice offered by several writers to the effect that model fit should be evaluated from multiple perspectives (Fabrigar & Wegener, 2014; Klem, 2000; Marsh, 2007).

In accordance with these recommendations, several fit indices were used to supplement the traditional chi-square test in order to evaluate the adequacy of the proposed model. On the basis of the suggestions of Marsh (2007), the selected indices were the CFI, TLI, and the RMSEA. The chi-square to degrees of freedom ratio (CMIN/*df*) statistic was also consulted for this purpose. The obtained chi-square and CMIN/*df* statistics for the specified model are reported in Table 5.16, while the descriptive fit indices are provided in Table 5.17. For each fit statistic or index, the hypothesized model (default model) is compared to that of a 'best-fit' (saturated model) and/or a 'no-fit' (independence) model.

Table 5.16

Chi-Square and Chi-Square/df Statistics for the Specified Model

Model	CMIN	*df*	*p*	CMIN/*df*
Default model	351.40	178	0.000	1.97
Saturated model	0.00	0		
Independence model	1677.30	210	0.000	7.98

Note. CMIN: Chi-square minimum
df: Degrees of freedom
p: Probability value

As observed in Table 5.16, the computed chi-square test statistic for the specified model suggested that the model was not a good fit for the sample data (chi-square = 351.40, df = 178, p = 0.000). As noted earlier, a good fit is indicated by a low chi-square value, which would imply that the deviation between the model and data is small (Biddle & Marlin, 1987; Klem, 2000). Also, the probability value of the obtained chi-square statistic should not be significant. A significant chi-square test statistic could indicate, among other factors, that the model has been poorly specified or that certain statistical assumptions have not been satisfied (Marsh, 2007). On the basis of the CMIN/*df* statistic (1.97), however, the model fit appeared to be reasonable. It has been proposed that values below 5.0 indicate an acceptable degree of correspondence between the model and data set (Klem, 2000).

Table 5.17

Descriptive Goodness-of-Fit Indices for the Specified Model

Model	CFI	TLI	RMSEA
Default model	0.88	0.86	0.07
Saturated model	1.00		
Independence model	0.00	0.00	0.18

With regard to the descriptive fit indices for the specified model, Table 5.17 shows that the obtained CFI and TLI values were 0.88 and 0.86, respectively, while the RMSEA estimate was 0.07. Published guidelines suggest that CFI and TLI values above 0.90 imply an acceptable fit, while values exceeding 0.95 indicate an excellent fit between model and data (Marsh, 2007). Consequently, it seemed that the fit of the specified model was not sufficiently adequate. For the RMSEA index, values between 0.05 and 0.08 imply a reasonable fit between model and data, while values below 0.05 indicate a close-fitting model (Marsh, 2007). Therefore, on the basis of the RMSEA index, the fit of the specified model appeared to be satisfactory.

In summary, of the five goodness-of-fit statistics and indices examined in this study, only two provided support for the acceptance of the specified model. Consequently, based on the totality of evidence, it was concluded that the posited model was plausible yet was not sufficiently adequate and could be improved upon.

Model Modification

The outcome of the goodness-of-fit assessment determines decisions and subsequent actions concerning model modification (Klem, 2000). Should it be found that the specified model is an inadequate fit for the data, it may be respecified and retested (Whittaker, 2012).

Since there was sufficient evidence to reject the hypothesized model, consideration was given to the manner in which the model could be improved. The process of model modification has been described as the practice of changing the original model on the basis of the obtained SEM results (Klem, 2000; Marsh, 2007). Model modification or respecification represents an exploratory rather than an a priori or confirmatory approach (Whittaker, 2012). Thus, on this basis, the modified model should be distinguished from the original hypothesized model, which is theory-driven (Klem, 2000; Whittaker, 2012).

In modifying an original model, the researcher may attempt to simplify the model by removing irrelevant or nonsignificant parameters (Klem, 2000). New linkages may also be added in order to improve model fit (Klem, 2000; Whittaker, 2012). Although a common practice, all post hoc modifications should be justifiable (Marsh, 2007). For instance, it is important that model revision is not guided by statistical criteria alone (Anderson & Gerbing, 1988). In particular, post hoc modifications should be consistent with theory and empirical research (Anderson & Gerbing, 1988; Marsh, 2007; Whittaker, 2012). This strategy is designed to help ensure that the modified model does not reflect chance characteristics of the specific research sample (Anderson & Gerbing, 1988; Whittaker, 2012).

Against this background, steps were taken to respecify the original model on the basis of the obtained SEM results and in accordance with existing theory and research. Initially, the measurement component of the model was examined. This entailed an inspection of the parameter estimates that represented the factor loadings of the latent variables on their corresponding measured indicators. The purpose of this exercise was to determine the extent to which each set of indicators was influenced by the underlying latent variable or construct.

It has been stated that in confirmatory factor analysis models, factors should ideally be overdetermined. This means that they should exert substantial effects on a minimum of three to five observed measures (Fabrigar & Wegener, 2014). In general, factor loadings should be at least 0.40 in order to be of significance in defining a factor (Ford, MacCallum & Tait, 1986). This implies that some of the factors in the specified model may have been undetermined. For example, two of the four factor loadings of training load (0.38 and 0.19) were below this value, while two of the running injury factor loadings (0.42 and 0.47) only marginally exceeded this level (see Table 5.9).

In SEM, both the structural and measurement components of a model contribute towards its overall adequacy (Fabrigar & Wegener, 2014). Thus, since the measurement component of the specified model may have been implausible, an SEM path analysis approach was explored as an alternative to the original full structural equation model.

SEM Path Analysis Model

An SEM path analysis model represents a special application of SEM and involves structural relationships between observed or measured variables (Klem, 2000). Therefore, unlike a full model, it does not include any unobserved variables or factors. Consequently, the model excludes a measurement component that represents the relations between factors and their indicators, as in confirmatory path analysis. The parameter estimates obtained from an SEM path analysis and a conventional path analysis are equivalent (Klem, 2000). However, in contrast with traditional path analysis, SEM software also provides data concerning model fit (Klem, 2000). Nevertheless, SEM path analysis differs from a full or general SEM model in several respects. First, it assumes that all variables are perfectly measured. Second, its effects and explanatory power are usually weaker, although the same substantive conclusions may be drawn (Klem, 2000).

SEM Path Analysis Model Specification

In an attempt to simplify the original structural equation model, various nonsignificant or seemingly irrelevant parameters were removed. These included the directional path linking running addiction to URTIs, and the various linkages involving training load, most of which were not statistically significant. Although running addiction was found to predict training load, all of the other hypothesized associations involving the latter variable were not statistically significant.

As the fit of a model may be improved by adding new linkages (Klem, 2000; Whittaker, 2012), a directional path was added between task goal orientation and running addiction. The inclusion of this path could be justified on the basis that there is some empirical support for this relationship (Hall et al., 2007a). Also, a statistically significant relationship was found between these constructs in correlational analysis of the study data (see Table 5.7).

The various structural paths leading from perfectionism (i.e., perfectionistic concerns, perfectionistic strivings, and parental perceptions), Type A behaviour, and ego goal orientation to running addiction, and from running addiction to running injuries were retained in the modified model. The injury indicator with the lowest factor loading (i.e., injury number) was, however, excluded. The proposed path analysis model featuring hypothesized directional relations among the measured variables is pictured in Figure 5.6.

As Figure 5.6 depicts, the proposed SEM path analysis model incorporated 11 measured variables, comprising six exogenous variables and five endogenous variables. The six measured, exogenous variables in the model included parental perceptions, perfectionistic concerns, perfectionistic strivings, Type A behaviour, ego goal orientation, and task goal orientation. The five measured, endogenous variables were running addiction, injury duration, injury severity, injury history, and injury time loss. The model also included five unmeasured, exogenous variables that represented error variance in the endogenous variables. (The error terms are not pictured in the path diagram).

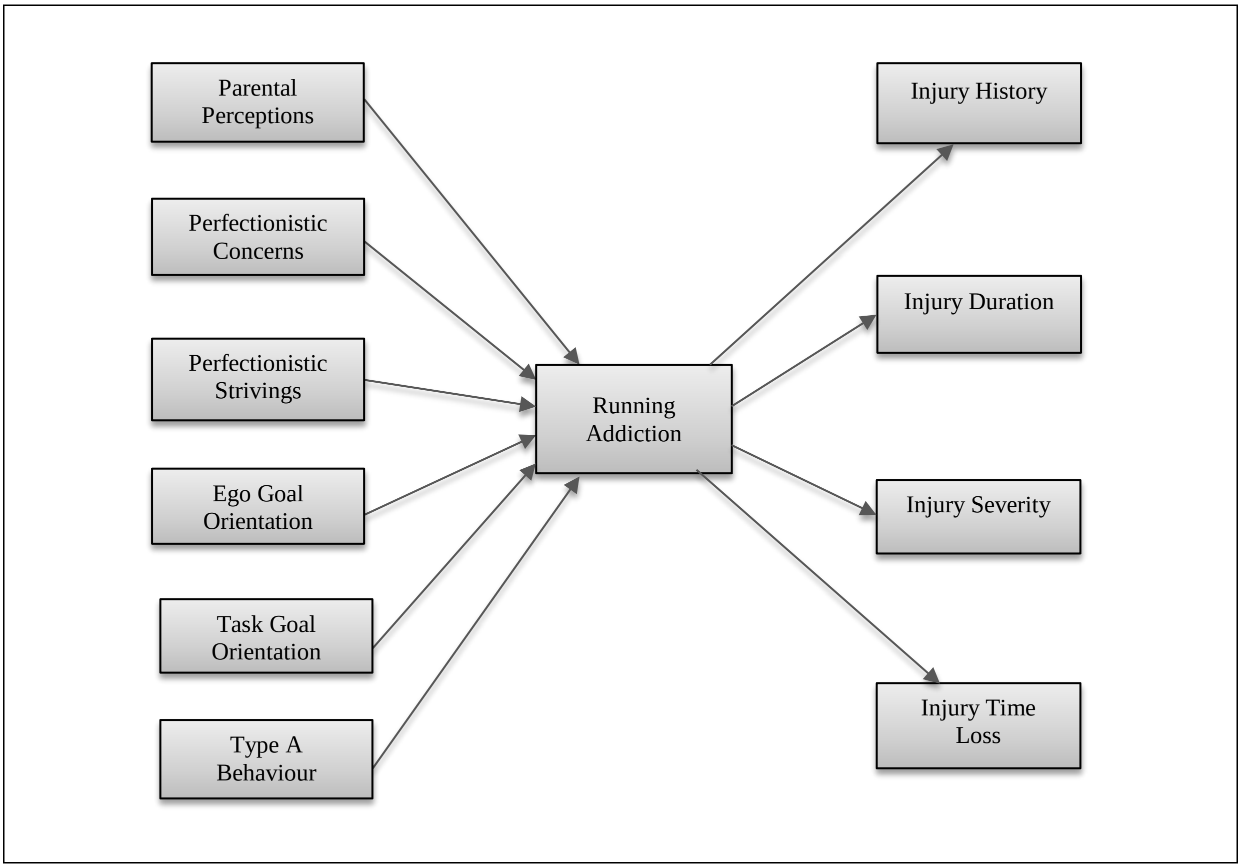

Figure 5.6. SEM Path Analysis Model of Personality, Motivation, Running Addiction, and Running Injuries

Figure 5.6 also illustrates that the specified path analysis model described a number of prospective directional or 'causal' relations among the exogenous and endogenous variables. Consistent with the original research hypotheses, these relations included the direct effects of perfectionism (i.e., perfectionistic concerns, perfectionistic strivings, and parental perceptions), Type A behaviour, and ego goal orientation on running addiction, and the effects of running addiction, in turn, on running injuries. As mentioned, the revised model also included a directional path between task goal orientation and running addiction.

SEM Path Analysis Model: Parameter Estimation

In testing the specified SEM path analysis model, parameter estimates of the coefficients representing directional and nondirectional relations in the model were obtained. The nonstandardized and standardized regression weights representing the direct effects of the personality and motivation variables on running addiction and its effect, in turn, on running injuries are displayed in Tables 5.18 and 5.19, respectively.

Table 5.18

Nonstandardized Regression Weights Representing Direct Effects in the SEM Path Analysis Model

Predictor Variable	Path	Dependent Variable	Estimate	SE	CR	*p*
Parental Perceptions	--->	Running Addiction	-0.04	0.05	-0.86	0.387
Perfectionistic Concerns	--->	Running Addiction	0.09	0.04	2.44	0.015
Perfectionistic Strivings	--->	Running Addiction	0.10	0.07	1.49	0.136
Type A Behaviour	--->	Running Addiction	0.03	0.01	2.11	0.035
Ego Goal Orientation	--->	Running Addiction	-0.03	0.05	-0.60	0.555
Task Goal Orientation	--->	Running Addiction	0.21	0.07	2.87	0.004
Running Addiction	--->	Injury Severity	0.03	0.02	1.67	0.094
Running Addiction	--->	Injury Duration	0.45	0.17	2.63	0.009
Running Addiction	--->	Injury History	0.22	0.08	2.73	0.006
Running Addiction	--->	Injury Time Loss	0.57	0.24	2.35	0.019

Note. SE: Standard error
CR: Critical ratio (nonstandardized estimate/standard error)
p: Probability value

As seen in Tables 5.18 and 5.19, several of the path coefficients representing directional relationships in the SEM path model were statistically significant at the 0.05 probability level or better. As expected, running addiction was predicted by perfectionistic concerns (0.09, SE = 0.04, CR = 2.44), Type A behaviour (0.03, SE = 0.01, CR = 2.11), and task goal orientation (0.21, SE = 0.07, CR = 2.87). In terms of the relative effects of the explanatory variables on the outcome variable, the standardized regression weights displayed in Table 5.19 demonstrate that the strongest predictor of running addiction was perfectionistic concerns (0.20), followed by task goal orientation (0.19), and Type A behaviour pattern (0.14). It was also found that running addiction, in turn, had a significant positive effect on injury duration (0.45, SE = 0.17, CR = 2.63), injury history (0.22, SE = 0.08, CR = 2.73), and injury-related training time loss (0.57, SE = 0.24, CR = 2.35). The structural paths from ego goal orientation, perfectionistic strivings, and parental perceptions to running addiction and from running addiction to injury severity were not statistically significant.

Table 5.19

Standardized Regression Weights Representing Direct Effects in the SEM Path Analysis Model

Predictor Variable	Path	Dependent Variable	Estimate
Parental Perceptions	--->	Running Addiction	-0.06
Perfectionistic Concerns	--->	Running Addiction	0.20*
Perfectionistic Strivings	--->	Running Addiction	0.12
Type A Behaviour	--->	Running Addiction	0.14*
Ego Goal Orientation	--->	Running Addiction	-0.04
Task Goal Orientation	--->	Running Addiction	0.19**
Running Addiction	--->	Injury Severity	0.11
Running Addiction	--->	Injury Duration	0.17**
Running Addiction	--->	Injury History	0.18**
Running Addiction	--->	Injury Time Loss	0.16*

Note. ** Significant at the 0.01 level (2-tailed)
* Significant at the 0.05 level (2-tailed)

A number of variables in the model were significantly interrelated. The computed observed covariances and correlation coefficients representing significant bivariate relations among the exogenous variables are provided in Tables 5.20 and 5.21. As seen in Table 5.20, perfectionistic strivings was positively related to perfectionistic concerns (19.77, SE = 2.77, CR = 7.12), parental perceptions (8.31, SE = 1.74, CR = 4.78), Type A behaviour (24.64, SE = 5.09, CR = 4.84), and ego goal orientation (4.94, SE = 1.51, CR = 3.26). Further, perfectionistic concerns was positively correlated with parental perceptions (23.87, SE = 3.62, CR = 6.60) and ego goal orientation (11.71, SE = 2.85, CR = 4.11). Task and ego goal orientation were also positively related (4.00, SE = 1.23, CR = 3.24), while a significant negative correlation was found between parental perceptions and task orientation (-2.53, SE = 1.16, CR = -2.18). Table 5.21 indicates that the magnitude of the effect sizes ranged from r =

-0.13 for the association between task goal orientation and parental perceptions to $r = 0.52$ for the perfectionistic strivings–perfectionistic concerns relation.

Table 5.20

Covariances Representing Significant Relationships among the Exogenous Variables in the SEM Path Analysis Model

Exogenous Variable		**Exogenous Variable**	**Estimate**	**SE**	**CR**	***p***
Perfectionistic Strivings	<-->	Perfectionistic Concerns	19.77	2.78	7.12	0.000
Perfectionistic Strivings	<-->	Parental Perceptions	8.31	1.74	4.78	0.000
Perfectionistic Strivings	<-->	Type A Behaviour	24.64	5.09	4.84	0.000
Perfectionistic Strivings	<-->	Ego Goal Orientation	4.94	1.51	3.26	0.001
Perfectionistic Concerns	<-->	Parental Perceptions	23.87	3.62	6.60	0.000
Perfectionistic Concerns	<-->	Ego Goal Orientation	11.71	2.85	4.11	0.000
Parental Perceptions	<-->	Task Goal Orientation	-2.53	1.16	-2.18	0.029
Task Goal Orientation	<-->	Ego Goal Orientation	4.00	1.23	3.24	0.001

Note. *SE*: Standard Error
CR: Critical Ratio (unstandardized estimate/standard error)
p: Probability value

Table 5.21

Correlation Coefficients Representing Significant Relationships among the Exogenous Variables in the SEM Path Analysis Model

Exogenous Variable		**Exogenous Variable**	**Estimate**
Perfectionistic Strivings	<-->	Perfectionistic Concerns	0.52**
Perfectionistic Strivings	<-->	Parental Perceptions	0.32**
Perfectionistic Strivings	<-->	Type A Behaviour	0.29**
Perfectionistic Strivings	<-->	Ego Goal Orientation	0.20**
Perfectionistic Concerns	<-->	Parental Perceptions	0.48**
Perfectionistic Concerns	<-->	Ego Goal Orientation	0.25**
Parental Perceptions	<-->	Task Goal Orientation	-0.13*
Task Goal Orientation	<-->	Ego Goal Orientation	0.21**

Note. **Significant at the 0.01 level (2-tailed)
* Significant at the 0.05 level (2-tailed)

Tables 5.22 and 5.23 display the covariances and correlation coefficients reflecting the bidirectional associations among the set of running injury variables. As demonstrated, the four injury variables were all significantly interrelated, with the statistical significance of these associations all exceeding the 0.01 probability level. The magnitude of these correlations ranged from r = 0.53 for the relationship between injury history and injury-related training time loss to r = 0.20 for the injury duration–injury history relation.

Table 5.22

Covariances Representing Interrelationships among the Injury Variables in the SEM Path Analysis Model

Injury Measure		**Injury Measure**	**Estimate**	**SE**	**CR**	***p***
Injury Severity	<-->	Injury Duration	4.46	0.74	5.99	0.000
Injury Severity	<-->	Injury History	1.98	0.34	5.76	0.000
Injury Severity	<-->	Injury Time Loss	7.03	1.07	6.54	0.000
Injury Duration	<-->	Injury History	9.01	3.06	2.94	0.003
Injury Duration	<-->	Injury Time Loss	49.32	9.74	5.06	0.000
Injury History	<-->	Injury Time Loss	33.22	4.81	6.91	0.000

Note. SE: Standard error
CR: Critical ratio (nonstandardized estimate/standard error)
p: Probability value

Table 5.23

Correlation Matrix Featuring Interrelationships among the Injury Variables in the SEM Path Analysis Model

Injury Measure	**IS**	**ID**	**IH**	**IT**
Injury Severity (IS)	1.00			
Injury Duration (ID)	0.44**	1.00		
Injury History (IH)	0.42**	0.20**	1.00	
Injury Time Loss (IT)	0.49**	0.36**	0.53**	1.00

Note. ** Significant at the 0.01 level (2-tailed)

The squared multiple correlation coefficients for the endogenous variables in the SEM path analysis model are reported in Table 5.24. As observed, the set of predictor variables comprising parental perceptions, perfectionistic concerns, perfectionistic strivings, Type A behaviour, task goal orientation, and ego goal orientation explained 13% of the variance in running addiction. Running addiction, in turn, accounted for 3% or less of the variance in each of the running injury variables.

Table 5.24

Squared Multiple Correlation Coefficients for the Running Addiction and Overuse Injury Variables in the SEM Path Analysis Model

Dependent, Measured Variable	**Estimate**
Running Addiction	0.13
Injury Duration	0.03
Injury Severity	0.01
Injury History	0.03
Injury Time Loss	0.03

SEM Path Analysis Model Fit Assessment

Following estimation of the model parameters, the fit of the SEM path analysis model to the data set was assessed. Once again, this process constituted an examination of the chi-square test statistic, the CMIN/*df*, the CFI, the TLI, and the RMSEA. The results of the chi-square test, as well as the CMIN/*df* value for the specified model, are reported in Table 5.25, while the descriptive goodness-of-fit indices are displayed in Table 5.26. To reiterate, for each fit statistic/index, the hypothesized model (default model) is compared to that of a 'best-fit' (saturated model) and/or a 'no-fit' (independence) model.

Table 5.25 shows that the computed chi-square test value indicated that the SEM path model was a good fit for the data (chi-square = 39.31, $df = 31$, $p = 0.145$). Also, the CMIN/*df* for the specified model was 1.27, which was well below the recommended threshold of 5.0 (Klem, 2000). As seen in Table 5.26, the obtained CFI and TLI values were 0.98 and 0.97, respectively, which is suggestive of an excellent fit (Marsh, 2007). The computed RMSEA value was 0.03, which provided further evidence of a close-fitting model (Marsh, 2007). Therefore, all of the five fit statistics and indices examined were in favour of the acceptance of the SEM path analysis model.

Table 5.25

Chi-Square and Chi-Square/df Statistics for the SEM Path Analysis Model

Model	**CMIN**	***df***	***p***	**CMIN/*df***
Default model	39.31	31	0.145	1.27
Saturated model	0.00	0		
Independence model	495.36	55	0.000	9.01

Note. MIN: Chi-square minimum
df: Degrees of Freedom
p: Probability value

Table 5.26

Descriptive Goodness-of-Fit Indices for the SEM Path Analysis Model

Model	**CFI**	**TLI**	**RMSEA**
Default model	0.98	0.97	0.03
Saturated model	1.00		
Independence model	0.00	0.00	0.19

The path analysis model with obtained parameter estimates is pictured in Figure 5.7. In the depicted path diagram, the coefficients beside the straight lines represent the magnitude of the effect of one variable on another. The coefficients next to the curved lines represent significant bivariate correlations among the exogenous and endogenous variables, respectively. The numbers that are displayed directly above each endogenous variable are their squared multiple correlation coefficients. These values reflect the proportion of variance in each dependent variable that is explained by its predictor variable(s). Unmeasured variables shown in circles that are linked to each endogenous variable are error terms. These variables represent the effects of factors omitted from the model.

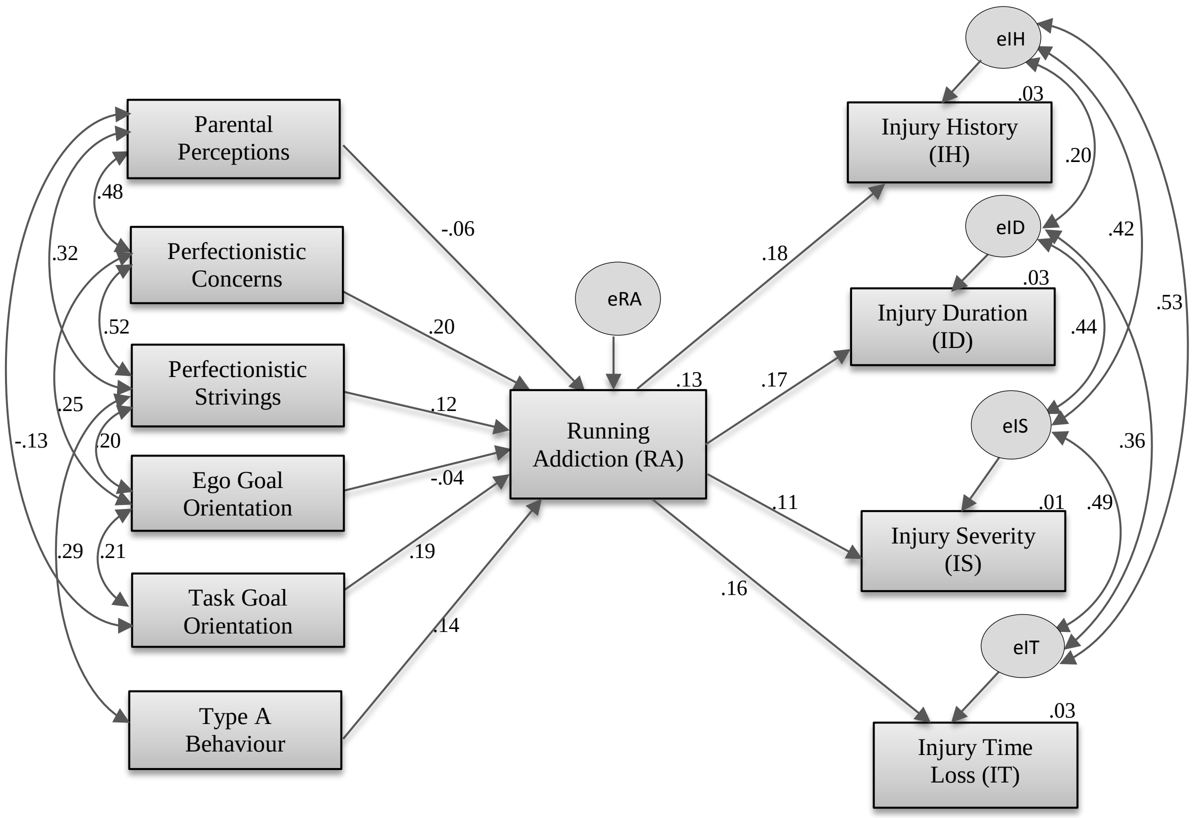

Figure 5.7. SEM Path Analysis Model of Personality, Motivation, Running Addiction, and Running Injuries with Obtained Parameter Estimates

SEM Path Analysis Model Modification

As explained, the SEM path analysis model described above was found to be a fairly good fit for the data. However, it was conceivable that the fit could possibly be improved by removing nonsignificant parameters and adding new structural relations that are supported by the literature. Thus, this model was slightly modified and then retested. These revisions included removing the paths linking parental perceptions, perfectionistic strivings, and ego goal orientation to running addiction, and running addiction to injury severity. Also, the measured variable, training workload, which formed part of the original structural equation model, was added to the model. In the initial SEM analysis, training workload (Volume × Intensity) was found to be the leading indicator of the training load factor, which was significantly related to running addiction. The running injury variable, injury number, was also incorporated in the modified model. The revised path analysis model is pictured in Figure 5.8.

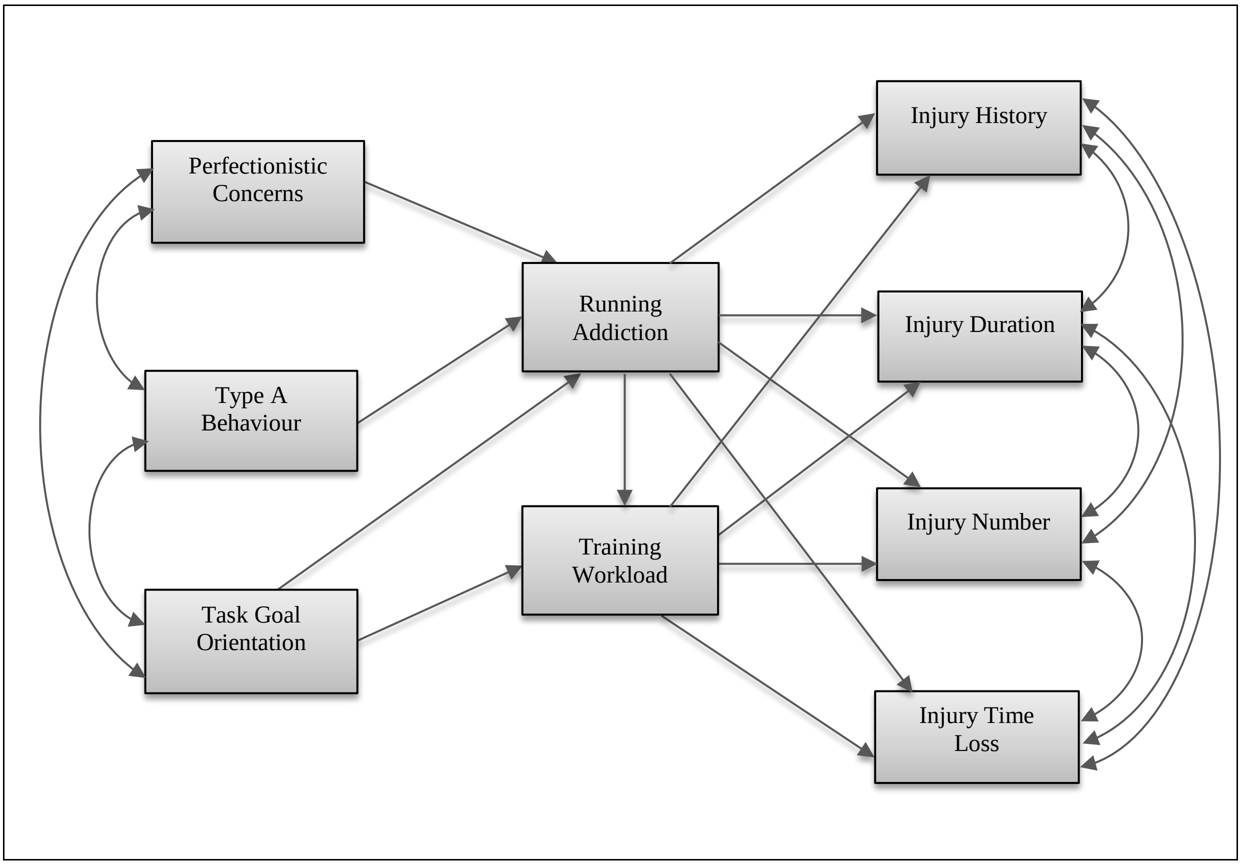

Figure 5.8. SEM Path Analysis Model of Personality, Motivation, Running Addiction, Training Workload, and Running Injuries

As depicted in Figure 5.8, congruent with the initial SEM path analysis model, the revised model included directional paths leading from perfectionistic concerns, Type A behaviour, and task goal orientation to running addiction, and from running addiction to the running injury variables. Consistent with the original research hypotheses, the model also featured structural paths linking task goal orientation and running addiction to training workload, and training workload, in turn, to running injuries. Paths from perfectionistic concerns and Type A behaviour to training workload were not specified as separate correlational statistical analysis did not support these relationships. Task goal orientation and training workload were, however, significantly related ($r = 0.19$, $p = 0.004$). The covariances shown among the exogenous and endogenous variables in the pictured model were automatically specified by the SEM statistical program. Nonstandardized and standardized parameter estimates for the modified SEM path analysis model are displayed in Tables 5.27 and 5.28, respectively.

Table 5.27

Nonstandardized Regression Weights Representing Directional Relationships in the Revised SEM Path Analysis Model

Predictor Variable	**Path**	**Dependent Variable**	**Estimate**	**SE**	**CR**	***p***
Task Goal Orientation	--->	Running Addiction	0.22	0.07	3.02	0.003
Perfectionistic Concerns	--->	Running Addiction	0.10	0.03	3.49	0.000
Type A Behaviour	--->	Running Addiction	0.04	0.01	2.78	0.005
Task Goal Orientation	--->	Training Workload	1.71	1.06	1.60	0.109
Running Addiction	--->	Training Workload	3.83	0.92	4.14	0.000
Training Workload	--->	Injury Time Loss	-0.04	0.02	-2.27	0.023
Training Workload	--->	Injury Duration	0.02	0.01	1.54	0.123
Training Workload	--->	Injury History	-0.01	0.01	-2.34	0.019
Training Workload	--->	Injury Number	-0.00	0.00	-2.49	0.013
Running Addiction	--->	Injury Time Loss	0.73	0.25	2.93	0.003
Running Addiction	--->	Injury Duration	0.37	0.18	2.09	0.037
Running Addiction	--->	Injury History	0.27	0.08	3.33	0.000
Running Addiction	--->	Injury Number	0.08	0.03	2.73	0.006

Note. SE: Standard Error
CR: Critical Ratio (Nonstandardized estimate/standard error)
p: Probability

As observed in Tables 5.27 and 5.28, most of the regression coefficients representing directional relations in the model were statistically significant. As expected, perfectionistic concerns, task goal orientation, and Type A behaviour significantly predicted running addiction, which, in turn, had a significant, direct effect on the running injury variables. Table 5.28 shows that the magnitude of these effects was either equivalent to or slightly larger than the previously-obtained regression weights. The path coefficients between running addiction and injury number (0.08, SE 0.03, CR = 2.73), and between running addiction and training workload (3.83, SE = 0.92, CR = 4.14), were also statistically significant. Training workload, in turn, exerted direct effects on injury history (-0.01, SE = 0.01, CR = -2.34), injury-related training time loss (-0.04, SE = 0.02, CR = -2.27), and injury number (-0.00, SE = 0.00, CR = -2.49). Contrary to expectations, however, the direction of these relations was negative. The associations between task goal orientation and training workload, and between training workload and injury duration, were not statistically significant.

Table 5.28

Standardized Regression Weights Representing Directional Relations in the Revised SEM Path Analysis Model

Predictor Variable	Path	Dependent Variable	Estimate
Task Goal Orientation	--->	Running Addiction	0.19**
Perfectionistic Concerns	--->	Running Addiction	0.22**
Type A Behaviour	--->	Running Addiction	0.18**
Task Goal Orientation	--->	Training Workload	0.10
Running Addiction	--->	Training Workload	0.27**
Training Workload	--->	Injury Time Loss	-0.16*
Training Workload	--->	URTI Duration	0.11
Training Workload	--->	Injury History	-0.16*
Training Workload	--->	Injury Number	-0.17*
Running Addiction	--->	Injury Time Loss	0.20**
Running Addiction	--->	Injury Duration	0.14*
Running Addiction	--->	Injury History	0.23**
Running Addiction	--->	Injury Number	0.19**

Note. ** Significant at the 0.01 level (2-tailed)
* Significant at the 0.05 level (2-tailed)

The squared multiple correlation coefficients computed for each endogenous variable in the revised SEM path analysis model are provided in Table 5.29. As shown, the set of predictor variables explained 12% of the variance in running addiction. This model also accounted for 9% of the variance in training workload, 6% of the variability in injury history, 5% of the variability in injury number and injury-related training time loss, and 4% of the variance in injury duration.

Table 5.29

Squared Multiple Correlation Coefficients for the Endogenous Variables in the Revised SEM Path Analysis Model

Dependent, Measured Variable	**Estimate**
Running Addiction	0.12
Training Workload	0.09
Injury Time Loss	0.05
Injury History	0.06
Injury Duration	0.04
Injury Number	0.05

The various fit statistics and indices computed for the modified path analysis model are reported in Tables 5.30 and 5.31.

Table 5.30

Chi-Square and Chi-Square/df Statistics for the Revised SEM Path Analysis Model

Model	**CMIN**	***df***	***p***	**CMIN/*df***
Default model	24.51	14	0.040	1.75
Saturated model	0.00	0		
Independence model	262.31	36	0.000	7.29

Note. MIN: Chi-Square Minimum
df: Degrees of Freedom
p: Probability

Table 5.31

Descriptive Goodness-of-Fit Indices for the Revised SEM Path Analysis Model

Model	**CFI**	**TLI**	**RMSEA**
Default model	0.95	0.88	0.06
Saturated model	1.00		
Independence model	0.00	0.00	0.17

As Table 5.30 indicates, both the chi-square statistic (chi-square = 24.51, *df* = 14, *p* = 0.04), and CMIN/*df* (1.75) suggested that the model was a reasonable-to-good fit for the sample data. CFI, TLI and RMSEA values of 0.95, 0.88, and 0.06, respectively, provided further support for the adequacy of the model. Therefore, the weight of evidence acquired from an inspection of several fit statistics and indices also supported acceptance of the second SEM path analysis model. However, the adequacy of the first path analysis model appeared to be superior. The second SEM path analysis model with obtained parameter estimates is pictured in Figure 5.9.

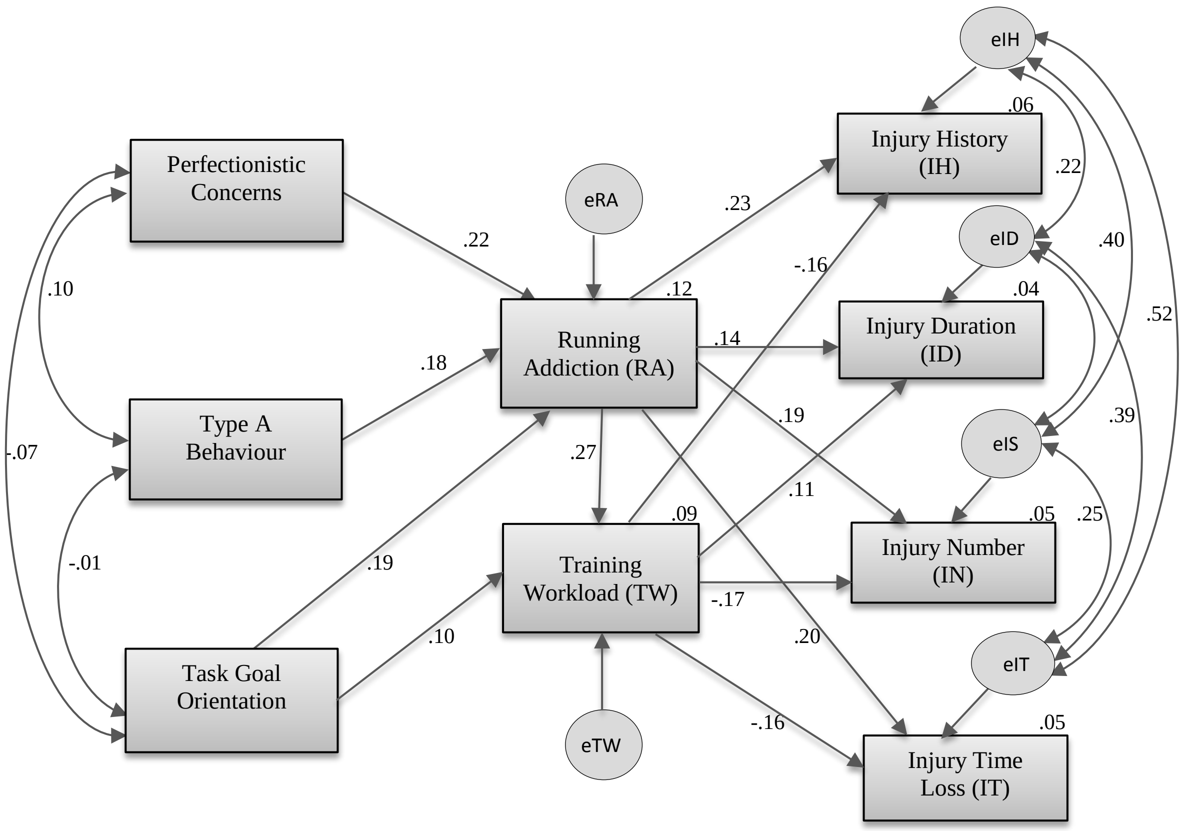

Figure 5.9. SEM Path Analysis Model of Personality, Motivation, Running Addiction, Training Workload, and Running Injuries with Obtained Parameter Estimates

In the depicted path diagram, the standardized regression weights representing the magnitude of the effects are displayed beside the straight lines with single-headed arrows. The correlation coefficients are shown next to the curved lines with double-headed arrows, while the squared multiple correlations are displayed above each endogenous variable, which are represented by rectangles. The unmeasured variables shown above each endogenous variable and which are represented by circles are error variables.

The results yielded by the statistical analyses of the study data, as reported in this chapter, are discussed in greater depth in the following chapter.

CHAPTER 6

DISCUSSION

The main objective of this study was to investigate the predictors of specific physical and psychological health risks associated with distance running. Structural equation modelling (SEM) was employed to explore the effects of perfectionism, Type A behaviour pattern, and achievement goal orientations on running addiction and training load and the impact of these variables, in turn, on self-reported running injuries and upper respiratory tract infections (URTIs). The effects of running addiction on training load and specific interrelationships among perfectionism, Type A behaviour, and achievement goal orientations were also examined.

A number of research hypotheses, informed by relevant theory and research, were tested. It was hypothesized that perfectionism, Type A behaviour pattern, and ego goal orientation have direct, positive effects on running addiction risk, while these personality and motivation variables, along with task goal orientation, also predict heavier training loads. It was further expected that running addiction has a direct, positive effect on training load, and that both running addiction and training load increase susceptibility to running injuries and URTIs. Various bivariate relationships among the exogenous variables were also predicted.

The main goal of this chapter is to discuss the results yielded by the SEM analysis in relation to the research hypotheses and pertinent theory and research. Prior to this, the results of descriptive statistical analysis of the data will be discussed.

Descriptive Statistics

Perfectionism

Perfectionism has been defined as a multidimensional personality trait comprising a combination of very high personal standards and overly critical self-evaluations (Frost et al., 1990). Three measured variables or indicators were used to create the perfectionism factor in a structural equation model. The Personal Standards subscale of the Multidimensional

Perfectionism Scale (MPS) (Frost et al., 1990) was employed to assess the indicator, perfectionistic strivings, while the Concern over Mistakes and Doubts about Actions subscales were used to measure perfectionistic concerns. A third measured variable, parental perceptions, was assessed by combining the MPS subscales, Parental Expectations and Parental Criticism.

Participants' scores on the various MPS subscales suggest that the average respondent displays moderate to high levels of perfectionistic strivings and moderate to low levels of perfectionistic concerns. In general, therefore, runners in this study may be inclined to set high personal standards of performance. Some researchers have proposed that this dimension of perfectionism is analogous with the trait of conscientiousness (Flett & Hewitt, 2002). This facet of the construct also typically characterizes people who are highly competent and successful (Frost et al., 1990). It seems that the research participants are generally not unduly concerned about making mistakes nor do they experience a sense of uncertainty about the quality of their performance. Consequently, this group do not appear to be overly self-critical. Scores for the parental perceptions variable indicate that individuals in this study do not seem to feel that their parents were excessively critical or set overly high standards of performance. Therefore, in terms of the trait of perfectionism, the typical respondent seems to be quite well adjusted.

These results are largely congruent with previous research conducted in athletic populations. For example, Hall et al. (2007a) found that British distance runners recorded lower scores on the Doubts about Actions, Concern over Mistakes, Parental Expectations, and Parental Criticism subscales of the MPS and slightly higher scores on the Personal Standards subscale. Lower levels of maladaptive perfectionism and higher levels of adaptive perfectionism were also observed in another group of distance runners (Hall et al., 2009) and in junior-elite male athletes (Appleton et al., 2009). A similar trend has been noted in several non-athletic populations, including undergraduate students (Longbottom et al., 2012), clinical psychologists (D'Souza et al., 2011), young adults (Molnar et al., 2006), and members of the general population (Flett et al., 1994). Therefore, the distribution of perfectionism scores in runners and non-runners seems to be relatively alike.

Type A Behaviour Pattern

The Type A behaviour pattern can be conceptualized as a broad personality dimension characterized predominantly by excessive achievement striving, competitiveness, impatience, time urgency, and anger/hostility (Blumenthal et al., 1985; Fields et al., 1990; Smith & Anderson, 1986; Steinberg, 1985; Thoresen & Powell, 1992).

Almost 42% of respondents in the present study obtained a score of 120 or higher on the Type-A Self-Rating Inventory (TASRI) (Blumenthal et al., 1985), which was used to assess the Type A construct in this study. Fields et al. (1990) proposed that individuals scoring above this threshold could reasonably be considered to display the Type A behavioural pattern. Applying this criterion, it seems that a fairly large percentage of the sample can potentially be described as 'Type A'.

The proportion of participants in this study exhibiting the Type A behavioural pattern corresponds with the findings of other research employing the TASRI. In an investigation involving distance runners, Fields et al. (1990) found that 35% of respondents could be classified as Type As. In general population research, it was observed that 39.5% of participants scored above 120 on the TASRI (Blumenthal et al., 1985). Studies employing various alternative measures of the construct have reported Type A prevalence rates of 57% (Sogaard et al., 2008), 53% (Burnman et al., 1975), and 30% (Ward & Eisler, 1987) in non-athletic populations. In Blumenthal et al.'s (1985) investigation, a structured behavioural interview classified 16.7% of participants as full Type A individuals and 48% as partial Type As (Blumenthal et al., 1985). These discrepancies suggest that the reported prevalence of Type A behaviour may vary according to the specific measuring instrument employed.

Achievement Goal Orientations

Achievement goals describe the aim or purpose of a person's behaviour in achievement-related contexts (Conroy & Hyde, 2014). Task goals are focused on the development of competence, while ego goals are concerned with the demonstration of ability (Elliot & Thrash, 2001). Achievement goal orientations refer to learned tendencies to be task and/or ego involved in achievement contexts (Roberts et al., 2007; Roberts et al., 1998).

The Perception of Success Questionnaire (Roberts et al., 1998) was used to assess achievement goal orientations in this study. Scores recorded for this measure suggest that the current respondents have a fairly strong tendency to endorse task goals and a much lower inclination to endorse ego goals in sporting contexts. Thus, in achievement domains, self-improvement and mastery motives may predominate among this group of runners. Accordingly, ability is likely to be self-referenced or task-referenced in these individuals (Roberts et al., 2007). It appears that participants are only somewhat predisposed to endorse ego goals, suggesting that self-presentation motives are of moderate importance. Also, self-worth is unlikely to depend on outperforming others or not doing worse than others (Elliot & Thrash, 2001). Thus, competence is not liable to be other-referenced among members of the present sample (Roberts et al., 2007).

The finding that participants in this study are quite strongly task-orientated and only moderately ego-orientated is consistent with other research. For example, the distribution of scores in this investigation exhibits a high degree of correspondence with the results of a previous study involving British distance runners (Hall et al., 2007a). This similarity exists despite the use of dissimilar measures of the goal orientation construct in the two studies. In general population research, high levels of task goal orientation and moderate levels of ego orientation have also been reported (Tenenbaum et al., 2005).

Running Addiction

Running or exercise addiction may be defined as a multidimensional construct comprising maladaptive psychological, social, physiological, and behavioural dimensions. Consistent with this conceptualization, a slightly modified version of the Exercise Addiction Inventory – Short Form (EAI) (Terry et al., 2004) was used to assess the construct of running addiction in this study. This instrument is a brief, theory-based, multidimensional screening tool incorporating the hypothesized six related components of behavioural addiction: salience, mood modification, tolerance, withdrawal symptoms, conflict, and relapse.

Based on classification criteria proposed by the developers of the EAI (Terry et al., 2004), an overwhelming majority of runners in this study (98.2%) reported varying degrees of running addiction symptoms. Less than 2% of the sample could be described as symptom-free. A total of 37 participants obtained a score of 24 or higher on the slightly modified version of the EAI

(Terry et al., 2004). Individuals scoring within this range responded with *agree* or *strongly agree* to most of the items and can be considered at risk for exercise addiction (Terry et al., 2004). Employing this criterion, 16.8% of the current respondents can be placed within the at-risk category. This group comprises 21.3% of female and 13.8% of male participants. Therefore, a slightly higher risk for running addiction was detected among women runners. A high percentage of runners (81.4%) scored between 13 and 23 on the EAI. Terry et al. (2004) described individuals with scores falling within this range as symptomatic. The results suggest that a higher proportion of male (84.5%) compared to female participants (76.6%) can be considered symptomatic. Less than 2% of the sample obtained a score of 12 or lower and can therefore be classified as asymptomatic (Terry et al., 2004).

The proportion of runners found to be at risk for exercise addiction in this study is higher than recent estimates recorded for general exercisers and students. It has been proposed that 10% of physically active individuals and 3% to 5% of the general population fall within the at-risk category (Downs & Hausenblas, 2014). For example, researchers have reported exercise addiction prevalence rates ranging from 7.2% (Miller & Mesagno, 2014) to 13.4% (Hausenblas & Downs, 2002b) among gym attendees. Investigations involving college students indicate that between 3.6% and 5% of this population could be classified as at risk for exercise addiction (Downs et al., 2004). The above estimates are based on studies that have utilized multidimensional measures of exercise addiction, such as the EAI (Terry et al., 2004), Exercise Dependence Scale (Hausenblas & Downs, 2002b), and Exercise Dependence Scale-Revised (Downs et al., 2004).

Although the prevalence of exercise addiction in this study generally exceeds frequently reported rates, the results are broadly consistent with research involving endurance athletes. The findings also support the view that exercise addiction is higher among individuals who are strongly committed to exercise relative to the general population (Hall et al., 2009). In an investigation involving a large sample of triathletes (*N* = 1 285), Youngman and Burnett (2008) found that 19.9% of participants could be considered at risk for exercise addiction on the basis of their EAI scores. Other researchers observed that 11% of a mixed group of competitive endurance athletes appeared to be vulnerable to the disorder based on scores obtained on the unidimensional Running Addiction Scale (RAS) (Hamer et al., 2002). In validating the RAS, the developers reported that 20.3% of the sample of runners could be placed in a high addiction category, 61.3% in a medium addiction category, and 18.3% in a low addiction category (Rudy & Estok, 1989). Utilizing another unidimensional measure of running addiction, South African researchers found that 22.5% of runners could be assigned to a high addiction group, 50% to a moderate addiction group, and 27.5% to a low addiction group (Basson, 2001).

Nevertheless, some investigators have reported running addiction prevalence rates that are either considerably higher or lower than the apparent norm. For example, based on scores obtained on the Exercise Dependence Questionnaire, Hall et al. (2009) found that 52% of participants could be classified as potentially addicted to running. Conversely, researchers utilizing the Exercise Dependence Scale-Revised reported that only 3.2% of ultramarathon runners were at risk for running addiction (Allegre et al., 2006). The reason for these inconsistencies is unclear, although they may be due to characteristics that are unique to these specific samples. Also, prevalence rates may vary according to the measuring instrument employed (Berczik et al., 2012; Egorov & Szabo, 2013). The current observation that female distance runners have higher exercise addiction scores than males generally corresponds with the results of earlier studies conducted among endurance athletes (Hall et al., 2007a; 2009; Youngman & Burnett, 2008).

Training Load

Four measured variables, specifically training workload (Volume × Intensity), training frequency, competition frequency, and underrecovery, were used to represent the training load factor in this investigation. Self-reported training habits indicate that runners in this study generally run 4.3 times per week, covering a distance of 48.6 kilometres. This suggests that participants run an average of 11.3 kilometres during each training session. The self-reported customary intensity of training can be subjectively categorized as somewhat hard, corresponding to around 70% to 80% of maximum heart rate. On the basis of responses to the competition frequency measure, this group of runners appear to be quite avid competitors. The average individual tends to run about 14 races of at least four kilometres in distance each year. Most of these races are half-marathons or shorter-distance events. An assessment of training recovery-related practices found that respondents, on average, were slightly more likely than unlikely to disagree that they continue to train hard despite symptoms of physical strain, injury, or illness. As a whole, therefore, the research participants seem to be marginally more inclined to pay attention to, rather than disregard, training recovery-related needs.

The training behaviours of participants in this research are similar to the self-reported training habits of other mixed-gender running populations. For example, Fields et al. (1990) found that runners in their study ran an average of 46.4 kilometres each week over the 12-month study period. In a South African investigation, the number of self-reported weekly training sessions was 4.4 among female runners and 4.0 among male runners (Ellapen et al., 2013). In other research, monthly training logs revealed that participants ran 4.7 days per week and a total distance of 1 650 kilometres during the year (a weekly average of 32 kilometres) (Heath et al., 1991). In Hall et al.'s (2007a) investigation, respondents trained an average of 5.4 times per week, covering a total distance of 32.7 kilometres during this period. Another study involving British distance runners reported that participants exercised 4.8 days per week, running a total of 43.4 kilometres during this period (Hall et al., 2009). When calculating the average distance run per training session, participants in the present investigation seem to cover more distance in each workout compared to runners in other studies. This trend may be a reflection of South Africa's strong ultramarathon-running tradition.

Running Injuries

Running injuries in this research were operationally defined as self-reported running-related pain in one or more common running injury sites. These areas were the lower back, hip/pelvis/groin, buttock, upper leg, knee, lower leg, ankle, and foot. Five indicators – injury number, duration, severity, history, and training time loss – were used to represent the running injury factor.

Adopting a checklist approach to the assessment of this variable, it was found that the vast majority of participants (90%) had sustained one or more injuries within the previous three months. More than half of the sample (57%), and 63% of injured runners, had also experienced injury-associated training disruptions during this time. Total training time loss in relation to injury occurrences in these individuals amounted to about 17 days. However, it should be noted that in cases where these injuries were experienced concurrently, this figure is likely to be an over-estimate. Injured runners typically reported between two and three different injuries, each persisting for around 12 days. Self-reported injuries were generally associated with a low to moderate level of pain and debilitation. The most common injury site was the knee, followed by the lower back. The least common injury location was the buttock. An assessment of injury history found that the present group had infrequently experienced running injuries, especially of a more severe nature, over the preceding 12 months. Therefore, although most runners had reported recent running-related pain, injuries do not seem to have had a significant impact on running ability in the group as a whole over the previous year.

When comparing these results with other research and taking running exposure time into account, it is evident that the prevalence of running injuries in this study exceeds previously reported estimates. This observation is based on research that has assessed annual injury occurrence. In general, it seems that about 50% to 70% of runners sustain an injury causing training disruptions each year (Lewis et al., 2000). For example, Hoffman and Krishnan (2014) observed that 64.6% of 1 200 ultramarathon runners experienced an injury resulting in lost training days during the previous 12 months. This figure was similar to estimates reported by van Middelkoop et al. (2008) (i.e., 60%) and van Poppel et al. (2015) (i.e., 55%) in two other large-scale studies involving marathon runners. Although Fields et al. (1990) documented an annual injury prevalence of only 42%, the research sample was small (N = 40). At the other end of the scale, a South African study found that 90% of recreational half-marathon runners had sustained a running-related injury during the preceding 12 months (Ellapen et al., 2013). Injuries were defined as musculoskeletal complaints that were associated with distress or agony and prevented training for at least one day. The observed variation in documented running injury prevalence across investigations may be due to differences in injury definitions, study populations, and/or research designs (Lewis et al., 2000; Ryan et al., 2006).

The relatively high number of running injuries reported by participants in the present study compared with other research may partially be due to how running injury was defined. It is conceivable that injured runners may be over-represented when injuries are conceptualized in terms of self-reported running-related pain. This definition would include serious injuries, such as stress fractures, as well as more trivial complaints, like delayed onset muscle soreness (muscle stiffness) in response to intense exercise. Many researchers in this field have operationally defined running injuries as running-related physical complaints causing training disruptions or stoppages for a specific time period (Nielsen et al., 2012; Ryan et al., 2006). When applying this criterion, the results of the present investigation seem to be slightly more in line with other research. The finding that the knee was the most frequently injured anatomical site supports observations to this effect in other studies (Ellapen et al., 2013; Noakes & Granger, 2003; Peters & Bateman, 1983; Ryan et al., 2006; van Gent et al., 2007).

Upper Respiratory Tract Infections

Upper respiratory tract infection is a nonspecific term that refers to infections involving the nasal passages, sinuses, pharynx, larynx, trachea, bronchi, and middle ear (Sucher et al., 2010). URTIs include the common cold, sinusitis, pharyngitis, bronchitis, otitis media, and influenza. Five indicators – URTI number, duration, severity, history, and training time loss – were used to represent the URTI factor in a structural equation model in this study.

Self-report assessment of recent URTI incidence revealed that almost half of the study participants (47%) had experienced one or more bouts of the common cold, influenza, coughing, or sore throat during the preceding three months. Eighty-four percent of the group reporting infectious episodes – equivalent to more than one-third of the total sample (39%) – had experienced URTI-related training stoppages during this time. Total training time lost due to URTIs was in the order of eight days. The typical symptomatic participant had generally suffered about one infectious episode only. URTI symptoms in these runners had lasted approximately six days and had exerted a moderate impact on daily routines. A rating scale measure of recent URTI history revealed that runners in this study had seldom experienced infectious respiratory episodes, especially of a hindering nature, during the preceding 12 months.

Due to wide variations in how URTIs have been operationally defined and measured, it is difficult to perform valid comparisons with other studies. Also, seasonal variations in URTI incidence have been noted (Heath et al., 1991). However, when the available research is considered collectively and reported time frames are considered, the current results appear to broadly agree with other studies involving runners. In two separate investigations, 30% and 43.2% of respondents, respectively, experienced one or more bouts of the common cold, influenza, or sore throat in the two-month period prior to a road race (Nieman et al., 1989; Nieman et al., 1990b). Other researchers found that 66% of recreational runners had at least one infectious episode over a 12-month period (Heath et al., 1991). The average person experienced 1.2 infectious episodes during this time. When considering the duration of the assessment period in the latter study, it is evident that URTIs were more prevalent among the present sample (i.e., 47% of participants reported experiencing infectious episodes over a three-month period). However, the finding that the current study group experienced URTIs infrequently over the previous year is broadly consistent with Heath et al.'s (1991) observations. In general population research, only 27.1% of respondents experienced at least one clinically verified infectious episode over a 15-week period (Cobb & Steptoe, 1996). Therefore, the prevalence of URTIs in the current study seems to exceed the rate observed in non-runners. However, the use of dissimilar research methodologies may account for this difference.

Researchers assessing upper respiratory symptoms in the two-week interval following a marathon-type competition have reported incidence rates ranging from 33.3% to 68% (Robson-Ansley et al., 2012; Peters & Bateman, 1983; Peters et al., 1993; Peters et al., 1996). In one of these investigations, 85% of runners assigned to a high training status group reported post-race URTI symptoms (Peters et al., 1993). Self-reported symptoms in these runners lasted about six days. In all of these investigations, URTI symptom incidence was significantly higher in runners compared with non-running controls. On the basis of this research, it seems that URTIs were considerably less common in the current participants relative to runners having just completed a marathon or ultramarathon.

Structural Equation Modelling

At the outset, the set of research hypotheses was expressed in a structural equation model that comprised both a structural and measurement component. The structural submodel portrayed the predicted directional and nondirectional relations among factors in the study, while the measurement submodel depicted the pattern of associations between each set of indicators and their underlying latent constructs.

The results of the SEM statistical analysis indicated that the specified model was an inadequate fit for the study data and thus should probably be rejected. Therefore, in terms of SEM convention, steps were taken to modify the original model in an effort to achieve a better-fitting version. As the initial findings suggested that the measurement submodel may have been implausible, an exploratory path analysis model that incorporated only measured variables was specified and tested. It was found that this model, which included the personality, motivation, running addiction, and running injury variables from the first model, was a fairly good fit for the study data. However, as the model fit could potentially have been improved, a few modifications were made to this model, and it was retested. It was observed that the revised model was also a satisfactory fit for the study data. The set of results pertaining to each of the structural equation models tested will be discussed in turn.

Original Structural Equation Model

Measurement Model

The measurement component of the original full structural equation model expressed the effects or factor loadings of the latent variables on their respective indicators. This portion of the model is equivalent to confirmatory factor analysis. As previously described, three measured variables were employed to represent perfectionism (i.e., perfectionistic strivings, perfectionistic concerns, parental perceptions), and four indicators were selected for training load (i.e., training workload, training frequency, competition frequency, and underrecovery). The URTI and running injury factors were each denoted by five measured variables (i.e., URTI/injury number, severity, duration, history, and time loss).

The results of the SEM analysis revealed that all of the measured variables loaded significantly on their corresponding latent variables. The variable, perfectionistic concerns, was shown to be a relatively good indicator of perfectionism (0.87). In this case, the latent construct explained a significant proportion of the variance (76%) in the measured variable. Perfectionistic concerns comprised the Concern over Mistakes and Doubts about Actions subscales of the MPS (Frost et al., 1990). Perfectionistic strivings (0.63), which constituted the MPS Personal Standards subscale, and parental perceptions (0.57), which included the Parental Expectations and Parental Criticism subscales of the measure, were acceptable yet less adequate representatives of the construct.

Although the latent variable, training load, was found to exert a significant effect on each of its four indicators, half of these loadings were suboptimal in size. In general, factor loadings should be at least 0.40 in order to be of significance in defining a factor (Ford et al., 1986). While the loadings for training workload (Volume × Intensity) (0.76) and training frequency (0.66) were satisfactory, the loadings computed for competition frequency (0.38) and underrecovery (0.19) were below the recommended threshold. This suggests that the training load construct did not have a substantial influence on two of its indicators. Therefore, it was likely that the measured variables representing this factor did not constitute a coherent set.

Similar to training load, the results showed that two of the indicators selected for the running injury construct were only marginally acceptable. Although the factor loadings for injury severity (0.66), history (0.70), and time loss (0.76) appeared to be satisfactory, those computed for injury duration (0.47) and injury number (0.42) only just exceeded the recommended threshold. Therefore, the adequacy of this latent variable is questionable. With the exception of the URTI history indicator (0.55), the factor loadings for the URTI construct were moderate to good, ranging from 0.76 (URTI time loss) to 0.94 (URTI severity). On the whole, it seemed that the measurement submodel may not have been sufficiently adequate.

Structural Model

As described in Chapter 4, the structural component of the specified structural equation model depicted the hypothesized network of directional and nondirectional relations among the eight latent variables in the study. These predicted relations comprised the direct effects of perfectionism, Type A behaviour pattern, achievement goal orientations, and running addiction on training load, the impact of perfectionism, Type A behaviour, and ego orientation on running addiction, and the effects of training load and running addiction on URTIs and running injuries. This model also expressed the hypothesized bivariate associations between perfectionism and Type A behaviour, task and ego goal orientation, and perfectionism and task goal orientation. The structural component in SEM is analogous with a conventional path analysis model.

Effects of personality variables on running addiction risk and training load

A growing body of research suggests that personality traits may influence specific dimensions of exercise behaviour in running and non-running populations (Basson et al., 2001; Downs et al., 2004; Gulker et al., 2001; Hagan & Hausenblas, 2003; Hall et al., 2007a; 2007b; 2009; Hausenblas & Giacobbi, 2004; Hill et al., 2015; Lichtenstein et al., 2014; Miller & Mesagno, 2014; Taranis & Meyer, 2010). These personality variables include the traits of perfectionism (Downs et al., 2004; Gulker et al., 2001; Hagan & Hausenblas, 2003; Hall et al., 2007a; 2007b; 2009; Hill et al., 2015; Lichtenstein et al., 2014; Miller & Mesagno, 2014; Taranis & Meyer, 2010) and Type A behaviour pattern (Diekhoff, 1984; Ekenman et al., 2001; Fields et al., 1990; Goffaux & And, 1987; Hassmen & Koivula, 1998; Masters et al., 2003; Lidor, 2014; Rhodes, 2014; Yang et al., 2012).

Various theoretical viewpoints imply that maladaptive cognitions and/or stress-related factors associated with perfectionism and Type A behaviour could promote potentially unhealthy exercise behaviour in distance runners (Ellis, 2002; Martin et al., 1989). In support of the research hypotheses, structural equation modelling revealed that both perfectionism and Type A behaviour had an independent, positive effect on running addiction risk, which, in turn, predicted increased injury incidence. Therefore, these traits seem to be associated with a higher risk of pathological exercise behaviour in South African distance runners.

Considerable health benefits have been associated with endurance exercise (Dubbert, 2002; Khatri & Blumenthal, 2007; Landolfi, 2012; Paffenberger et al., 1986). However, an addiction to running could impair psychological, physical, and social functioning (Terry et al., 2004). In this case, running may cease to be a healthy pastime. The current findings are broadly consistent with research indicating that personality traits may influence dimensions of physical activity and exercise (Rhodes, 2014). They also provide support for the notion that personality dispositions may increase the risk for behavioural addictions (Zuckerman, 2012). However, each personality variable only explained a small proportion of the variance in running addiction (< 5%). Therefore, the practical significance of these findings could be debated.

The relationship found between perfectionism and running addiction risk (see Hypothesis 1 in Chapter 4) adds to the growing body of research suggesting that this personality trait may increase the risk for negative cognitions, affect, and outcomes in diverse populations (D'Souza et al., 2011; Flett et al., 2014; Frost et al., 1990; van Eijsden et al., 2004). The results are also consistent with investigations reporting positive associations between perfectionism and various dysfunctional behaviours, such as compulsivity (Frost et al., 1990), work addiction (Bovornusvakool et al., 2012), and alcohol-related problems (Rice & van Arsdale, 2010). More importantly, the current finding concurs with studies showing that both unidimensional and multidimensional perfectionism may increase exercise addiction incidence in college students and regular exercisers (Downs et al., 2004; Gulker et al., 2001;

Hagan & Hausenblas, 2003; Hill et al., 2015; Lichtenstein et al., 2014; Miller & Mesagno, 2014; Taranis & Meyer; 2010). Most significantly, the present results corroborate the findings of previous research demonstrating that perfectionism has direct, positive effects on exercise addiction and related constructs in distance runners (Hall et al., 2007a; 2007b; 2009). The exercise addiction measures employed in this body of research differed from those in the current investigation. Therefore, this may be one of the first studies to confirm a relationship between perfectionism and running addiction utilizing a theory-based measure of the latter construct.

From a theoretical standpoint, the results of this research support the proposed self-defeating nature of perfectionism in sport and exercise (Flett & Hewitt, 2005). As noted by Flett and Hewitt (2005), perfectionism should be regarded primarily as a negative trait contributing towards maladaptive outcomes among athletes and exercisers. Congruent with this notion, it appears that a combination of high personal standards and heightened concerns about performance may have adverse consequences in distance runners. Specifically, these individuals may be inclined to become preoccupied with running to the detriment of physical, psychological, and social functioning.

Several mechanisms may explain the association between perfectionism and running addiction. It is possible that dysfunctional beliefs about the role of achievement in self-worth may promote maladaptive achievement striving in runners who are psychologically invested in the sport (Hall et al., 2009). This may, in turn, contribute towards the development of an unhealthy preoccupation with the activity. Perfectionistic self-presentation concerns may also motivate and encourage a maladaptive focus on running with the aim of meeting impression management needs (Flett & Hewitt, 2005). For example, running may serve as an effective vehicle to obtain admiration from others and to enhance physical appearance. Moreover, as perfectionism is associated with increased perceptions of stress (Hewitt & Flett, 2002), some perfectionistic runners may become increasingly reliant on running as a way of coping with negative emotions. Ultimately, it is possible that these mechanisms, in combination, may explain the relationship between perfectionism and running addiction risk.

The discovery that Type A behaviour seems to increase the risk for running addiction (see Hypothesis 3 in Chapter 4) is compatible with research demonstrating that this trait may have various maladaptive correlates and consequences (Lee et al., 1993; Martin et al., 1989;

Sogaard et al., 2008; Ward & Eisler, 1987). In distance runners, Type A behaviour has also been linked to an increased risk for overuse injuries (Diekhoff, 1984; Ekenman et al., 2001; Fields et al., 1990). Higher injury incidence in Type A runners may be related to the adoption of dysfunctional training-related attitudes and behaviours (Ekenman et al., 2001; Fields et al., 1990). Examples of these tendencies include continuing to run despite experiencing pain or discomfort or resuming training too quickly after experiencing an injury (Ekenman et al., 2001; Fields et al., 1990). As these behaviours are typically associated with running addiction, it is possible that this construct may mediate the impact of Type A behaviour on injury incidence. The finding that Type A behaviour has an indirect effect on running injuries through running addiction is consistent with this idea. To the best of the author's knowledge, this study appears to be first to provide evidence that Type A behaviour may be a risk factor for potentially harmful exercise behaviour, and consequently, overuse injuries, in a running population.

Although it might be assumed that the Type A construct fosters higher levels of accomplishment, the results of the present research support the view that this disposition could have adverse outcomes (Ward & Eisler, 1987). Various factors could potentially explain an increased prevalence of running addiction in Type A individuals. First, these runners may use exercise as a means of coping with adverse emotions. It has been hypothesized and demonstrated that Type A behaviour may increase perceptions of stress and negative affect (Martin et al., 1989; Sogaard et al., 2008). According to some theorists, exercise addiction may function as a maladaptive coping mechanism (Berczik et al., 2012). In support of this, some investigators have reported that Type A behaviour may predict increased neuroticism, which has, in turn, exhibited a positive relationship with exercise addiction (Adams & Kirkby, 2001). Second, the hard-driving and competitive nature of Type A individuals, which is underpinned by self-worth concerns (Martin et al., 1989), may foster dysfunctional achievement striving in endurance sporting contexts. It is feasible that these tendencies, in isolation or combination, could lead to an all-consuming focus on training and competition, which may increase the risk for running addiction.

This study also assumed that perfectionistic and Type A runners, due to their high personal standards, fear of failure, and intense achievement drive, are apt to adopt heavy training loads (see Hypotheses 2 and 4 in Chapter 4). Contrary to expectations, however, neither perfectionism nor Type A behaviour had a significant, direct effect on training load in this group of runners. Both perfectionism and Type A behaviour were, however, related to running addiction which, in turn, exerted a direct, positive effect on training load.

The reason that neither perfectionism nor Type A behaviour exerted direct effects on training load is unclear. Still, the results are broadly consistent with those of Fields et al. (1990), who reported that Type A behaviour was unrelated to training volume. Compared to the present investigation, though, this study was relatively small (N = 40) and mainly involved male runners. Also, the effects of the Type A construct on variables like training frequency or intensity were not assessed. The impact of perfectionism on quantitative dimensions of endurance exercise behaviour does not seem to have been examined up to this point.

It is possible that the inability to detect a significant direct association between training load and the personality dispositions of Type A and perfectionism may partially reflect methodological shortcomings of the study rather than the absence of a substantive association between these constructs. As already mentioned, analysis of the measurement model revealed that the factor loadings of two of the indicators of training load (i.e., competition frequency and underrecovery) were suboptimal. It is also conceivable that the effects of these variables on training factors may vary according to factors like running experience and running-related goals. For example, it seems unlikely that a novice runner training for a 10 kilometre race would train at the same level as a seasoned marathon runner aiming for a personal best time. Even so, it is plausible that these traits may primarily predict inherently pathological exercise behaviour rather than potentially less harmful or more functional training patterns.

Effects of achievement goal orientations on running addiction and training load

According to achievement goal theory, task goal orientation is related to motives to develop competence, whereas ego goal orientation is linked to the desire to demonstrate ability (Elliot & Thrash, 2001). This theory predicts that task involvement promotes adaptive motivation-related behaviours, such as enhanced effort, persistence, and the selection of challenging goals (Elliott & Dweck, 1988; Roberts et al., 2007; Tenenbaum et al., 2005). Therefore, task goals may foster higher levels of motivation in runners who are actively involved in the sport, which could manifest in heavier training loads. Task goals are also likely to promote flexible achievement striving as self-worth is not contingent upon achievement (Hall et al., 2007a). Among ego-involved runners, the need to demonstrate competence and avoid displaying incompetence in order to affirm self-worth may lead to the adoption of maladaptive achievement strategies (Hall et al., 2007a). This may, in turn, result in more strenuous training regimens and/or contribute towards the development of running addiction.

SEM analysis of the data failed to provide support for any of the expected associations. Therefore, this study seems to indicate that achievement goal orientations do not predict more strenuous training schedules in runners, while ego goals do not increase the risk for running addiction.

The finding that task goal orientation was unrelated to training load (see Hypothesis 5 in Chapter 4) seems to be inconsistent with theory and research suggesting that task involvement may predict higher levels of achievement motivation (Biddle et al., 2003; Elliott & Dweck, 1988; Roberts et al., 2007; Tenenbaum et al., 2005). However, the use of a global measure of training load in the present study may have been problematic for two reasons. First, as mentioned previously, half the indicators of this construct did not exhibit satisfactory factor loadings. Second, it is plausible that task goals may only predict certain dimensions of training behaviour. For example, task goals may be unrelated to competition frequency measures as performance relative to others should be immaterial. Aside from these possibilities, it is feasible that, similar to perfectionism and Type A behaviour, the influence of task goals on measurable training behaviours may depend on factors like running experience and running-related goals. Therefore, although task-involved runners may generally be highly motivated, this may not automatically translate into a greater absolute amount of exercise.

The absence of a significant relationship between ego goal orientation and running addiction risk (see Hypothesis 6 in Chapter 4) was contrary to the results of Hall et al.’s (2007a) investigation. These researchers found that ego goals exerted an independent, positive effect on a measure of obligatory exercise behaviour in British distance runners. Further attesting to its possible association with maladaptive striving, ego goal orientation was shown to predict an increased risk of burnout in elite athletes (Lemyre et al., 2003). Theorists have maintained, however, that ego goal orientation is related to maladaptive achievement striving primarily when perceived competence is low (Hall et al., 2007a; Roberts et al., 2007; Tenenbaum et al., 2005). Conversely, when ego-involved individuals feel confident that they can demonstrate ability, adaptive achievement behaviours are probable. Therefore, the effect of ego goal orientation on running addiction risk may depend on perceived ability. Also, Grant and Dweck (2003) have identified three types of ego or performance goals, which may differ in terms of their adaptiveness. It has been posited that goals that are focused on self-validation (ability goals) are mainly dysfunctional, whereas motives to outperform others (normative goals) or to achieve a positive outcome (outcome goals) may have desirable consequences. In support of these ideas, various studies have shown that ego goal orientation is not inevitably maladaptive and could even have desirable consequences in a sporting domain (Biddle et al., 2003; Tenenbaum et al., 2005).

Effects of running addiction and training load on URTIs and running injuries

Physiological conceptions of stress and models of exercise and infection/injury imply that chronic physical and/or non-physical stress could have adverse physical health outcomes (Appaneal & Perna, 2014; Nieman, 2001; Selye, 1975). For instance, it has been postulated that heavy exercise can elicit neuroendocrine changes leading to immunosuppression and impaired muscle repair ability (Appaneal & Perna, 2014). This may, in turn, increase the risk of developing viral infections and overuse injuries. It was thus hypothesized that training load has a direct, positive effect on upper respiratory tract infections and running injuries. As individuals at risk for running addiction are likely to adopt heavy and/or dysfunctional training regimens, it was expected that running addiction would also increase susceptibility to URTIs and injuries in this population.

Only one of these hypotheses was supported. Specifically, running addiction was shown to exert an independent, positive effect on running injuries. Conversely, the results suggest that customary training load, which was represented by the measured variables of training workload (Volume × Intensity), training frequency, competition frequency, and underrecovery, does not influence running injury risk. Additionally, there was no evidence to support the contention that running addiction or training load has a significant impact on URTIs in this population.

The discovery that running addiction seems to increase injury susceptibility in South African distance runners (see Hypothesis 9 in Chapter 4) supports assertions pertaining to the potential harmful nature of exercise addiction (Berczik et al., 2012; Terry et al. 2004). The results also validate the widely-held belief that exercise addiction can increase athletic injury risk (Adams & Kirkby, 1998; Adams & Kirkby, 2001; Berczik et al., 2012; de Coverley Veale, 1987; Downs & Hausenblas, 2014; Gapin et al., 2009; Hays, 2004; Iannos & Tiggemann, 1997; Landolfi, 2012; Lichtenstein et al., 2014). Therefore, in common with other addictive disorders, an addiction to exercise may have adverse physical health effects. Individuals at risk for running addiction may tend to adopt dysfunctional training habits, which could predispose them to develop running injuries. These behaviours could include allowing insufficient recovery time between training sessions, training hard or competing when fatigued, ill, or injured, and/or failing to modify training levels during increased non-training stressor exposure. As a result of these practices, addicted runners may be more susceptible to training maladaptations and overuse injuries (Appaneal & Perna, 2014).

It is plausible that running addiction may also influence running injury risk through psychological pathways. According to some theorists, exercise addiction may increase psychosocial stress (Berczik et al., 2012), which has, in turn, exhibited positive associations with athletic injury incidence (Cramer & Perna, 2000; Galambos et al., 2005; Ivarsson & Johnson, 2010; Junge, 2000; May et al., 1985a; 1985b). Both physical and psychological stressors can promote adverse physiological and behavioural changes, such as impaired self-care and sleep quality, which could mediate the relationship between stress and athletic injury (Appaneal & Perna, 2014).

The finding that running addiction affects running injuries corroborates the results of a small body of research that has documented an association between exercise addiction and overuse injuries (Diekhoff, 1984; Ekenman et al., 2001; Layman & Morris, 1991; Lichtenstein et al., 2014; Rudy & Estok, 1989). However, this seems to be only the second study to find evidence for this association utilizing a theory driven, well-validated, multidimensional measure of exercise addiction. Previously, Lichtenstein et al. (2014) reported that general exercisers with higher scores on the EAI (Terry et al., 2004) reported significantly more bodily pain and overuse and acute injuries compared with non-addicted controls. The present investigation, however, seems to be the first to observe an association between scores on the EAI and overuse injuries in a running population.

The discovery that training load did not exert an independent effect on running injuries (see Hypothesis 11 in Chapter 4) suggests that habitual heavy training is not necessarily maladaptive in itself. Therefore, even though the results show that individuals at risk for running addiction are inclined to have higher training load scores, this does not seem to explain their higher injury incidence. The finding that heavier training loads do not increase running injury risk was, however, contrary to expectations and contradicts the findings of several previous studies. Other researchers have reported significant associations between injury susceptibility and various training behaviours (Diekhoff, 1984; Huxley et al., 2014; Layman & Morris, 1991; Nielsen et al., 2012; Ryan et al., 2006; van Gent et al., 2007; van Middelkoop et al., 2008). Another study found that runners with a higher training status had significantly elevated scores for MRI-assessed chronic knee lesions relative to runners with a lower training status (Schueller-Weidekamm et al., 2006). In several of these investigations, injury incidence was found to increase beyond a critical training threshold. For example, in Layman and Morris's (1991) study, 70.9% of athletes training more than 48 kilometres per week sustained an injury during the previous 12 months compared with only 51% of those running less than this distance. Other researchers reported that a training distance of less than 40 kilometres per week was a protective factor for calf injuries in male marathon runners (van Middelkoop et al., 2008).

Nevertheless, several researchers have found no relationship between injury risk and factors such as training volume (Ellapen et al., 2013; Fields et al., 1990; Hoffman & Krishnan, 2014; Nielsen et al., 2012; Rudy & Estok, 1989; van Gent et al., 2007), training frequency (Nielsen et al., 2012), or training intensity (pace) (Nielsen et al., 2012; van Gent et al., 2007; Schueller-Weidekamm et al., 2006). It has been proposed that these inconsistencies in the running injury research may reflect differences in study design, data collection methods, injury definitions, and running populations (van Gent et al., 2007).

It is possible that the relationship between training load and running injuries may be more complex than generally believed. For example, it has been postulated that a nonlinear, U-shaped relationship may exist between the frequency of training sessions and the risk of overuse injuries (Nielsen et al., 2012). Additionally, it is conceivable that individual factors like age, gender, running experience, and biomechanics may moderate the association between training habits and injury incidence. In support of this, there is stronger evidence for a link between training volume in male versus female runners (Nielsen et al., 2012; van Gent et al., 2007). It has also been shown that greater age may predict increased injury incidence (van Gent et al., 2007). Therefore, various factors may interact with training behaviours to influence running injury risk. One can further speculate that different dimensions of training may have dissimilar effects on injury incidence. Moreover, in the present study, confirmatory factor analysis of the data revealed that the four training load indicators did not constitute a coherent set. This may have also accounted for the research hypothesis being unsupported.

The discovery that neither running addiction nor training load affected URTI susceptibility (see Hypotheses 8 and 10 in Chapter 4) was also contrary to the research hypotheses and seems to contradict current theoretical perspectives. For example, the open-window theory of exercise and infection suggests that transient immunosuppression following acute heavy exercise provides pathogens with an opportunity to invade the system (Nieman, 2001). It follows that repeated bouts of strenuous exercise may increase the risk of infection. On the basis of this hypothesis and various research findings, it has been posited that a J-shaped relationship exists between exercise and infectious illness (Nieman, 2001). According to this formulation, heavy exercise increases URTI susceptibility, whereas regular, moderate exercise is protective against viral infections. Additionally, chronic heavy exercise and/or dysfunctional training habits may increase the risk of developing the overtraining syndrome (Adams & Kirkby, 2001). Among other impairments, overtrained individuals are more susceptible to infectious illness and overuse injuries (Adams & Kirkby, 2001; Meehan et al., 2002; Kellmann & Altfeld, 2014a; McKenzie, 1999; Meeusen et al., 2010, Noakes, 2001).

The current research findings also differ from the results of a number of earlier studies reporting positive associations between quantitative dimensions of distance running and URTI risk (Heath et al., 1991; Linde, 1987; Nieman et al., 1990b; Peters & Bateman, 1983; Peters et al., 1993; Robson-Ansley et al., 2012). Nevertheless, these observations have not been consistent. For example, despite linking higher annual training volume to increased URTI incidence in recreational runners, Heath et al. (1991) found no association between infectious episodes and weekly training volume, training frequency, or race participation during the previous year. In other studies, infectious symptoms were unrelated to any measures of training load (Ekblom et al., 2006; Fricker et al., 2005; Nieman et al., 1989; Struwig et al., 2006), while some researchers have reported inverse associations between these variables (Martensson et al., 2014; Nieman, 1997; Peters et al., 1996).

There may be several explanations for the present research results. First, the absolute amount of training performed may be less important than relative training load. For example, runners who customarily run more often, further, and/or harder than others, whether due to exercise addiction or other reasons, may have habituated to the stress of heavier training. Consequently, the risk of stress-induced immunosuppression may be minimized. Second, individual factors such as nutritional status, genetic predispositions, and fitness levels may influence the relationship between exercise and infection (Moreira et al., 2009). Third, as already mentioned, the training load factor in this study may have been underdetermined, which may have influenced the relationship between this variable and URTIs. Fourth, it is possible that the J-shaped curve may tend to flatten in highly fit athletes (Moreira et al., 2009). A combination of these and other factors not mentioned could explain why running addiction and training load did not exert a significant effect on infectious illness in this study.

Effects of running addiction on training load

According to models of exercise addiction, higher levels of running addiction are likely to predict heavier training loads. The findings of the present study support this assumption (see Hypothesis 12 in Chapter 4). This discovery extends previous research that has documented positive associations between exercise addiction and training frequency, intensity, and/or duration in general exercisers (Downs et al., 2004; Gapin et al., 2009; Hagan & Hausenblas, 2003; Hausenblas & Downs, 2002b; Iannos & Tiggemann, 1997; Lichtenstein et al., 2014; Terry et al., 2004) and endurance athletes (Youngman & Burnett, 2008). The current finding is also consistent with a large-scale study involving distance runners (Layman & Morris, 1991). The results of this particular investigation showed that symptoms of addiction are positively associated with training volume, training frequency, and race participation (Layman & Morris, 1991).

It seems, therefore, that the training habits of individuals at risk for running addiction may be more extreme in comparison to individuals with fewer addictive symptoms. There may be several reasons for this. For example, due to tolerance and withdrawal effects, addicted runners may be inclined to train frequently, intensely, and for long distances (de Coverley Veale, 1987; Downs & Hausenblas, 2014; Hausenblas & Downs, 2002a; Rudy & Estok, 1989). Tolerance describes the process whereby increasing amounts of an activity are needed to achieve certain desired effects, like a feeling of euphoria or escape (Terry et al., 2004). Withdrawal effects are the adverse physical and psychological symptoms that occur when an activity is discontinued or suddenly reduced (Terry et al., 2004). It is also possible that the intrapsychic and interpersonal conflict associated with running addiction could increase perceptions of stress in susceptible individuals. This may, in turn, encourage further exercise in a bid to cope with these negative emotions (Berczik et al., 2012).

Bivariate relationships

On the basis of various theoretical perspectives and previous research, it was hypothesized that certain predictor variables in the structural equation model were positively correlated. In support of these predictions, significant positive associations were found between perfectionism and Type A behaviour pattern, and between task goal orientation and ego goal orientation.

The relationship found between perfectionism and Type A behaviour (see Hypothesis 13 in Chapter 4) matches earlier research in college students (Flett et al., 1994; Flett et al., 2011). It also supports the contention that these personality variables have conceptual similarities, such as dimensions of high personal standards and intense achievement striving (Flett et al., 1994; Flett et al., 2011). The discovery of a positive association between perfectionism and Type A behaviour is also consistent with the finding that both factors seem to increase the risk for running addiction.

In the context of the 2 × 2 achievement goal framework, it has been stated that task and ego goals represent an approach as opposed to an avoidance orientation (Roberts et al., 2007). This implies that both goal orientations are focused on attaining desirable outcomes rather than on avoiding negative consequences (Elliot & Thrash, 2001). The discovery of a positive relationship between the two achievement goal constructs (see Hypothesis 15 in Chapter 4) supports this assumption and is consistent with previous research (Hall et al., 2007a; Ozkan et al., 2012). The current results are also compatible with the conceptualization of achievement goals as orthogonal or independent, which suggests that individuals may be high or low in one or both dimensions (Roberts et al., 2007; Roberts et al., 1998).

Although it was thought that perfectionists' need to be thoroughly competent in all tasks and avoid making mistakes of any kind may be incompatible with task-goal involvement in runners (see Hypothesis 14 in Chapter 4), this does not seem to the case. However, it is plausible that the different dimensions of perfectionism may be differentially related to the task goal construct. Whereas perfectionistic concerns may be inversely associated with task goals, perfectionistic strivings may have a positive relationship with this goal orientation.

Major Findings and Model Fit Assessment

Major findings that emerged from statistical analysis of the original structural equation model were that the hypothesized model explained 9% of the variance in running addiction, 18% of the variance in training load, 7% of the variance in running injuries, and a negligible amount of the variance in URTIs. In support of the research hypotheses, both perfectionism and Type A behaviour were found to exert direct, positive, effects on running addiction, which, in turn, had a direct, positive, impact on training load and running injuries. These findings imply that perfectionism and Type A behaviour may indirectly predict heavier training loads in runners and may also have an indirect, positive influence on running injury risk. However, most of these effect sizes were relatively small. As expected, significant bivariate associations were found between perfectionism and Type A behaviour, and between task goal orientation and ego goal orientation.

The assessment of model fit was described in some depth in the previous chapter. To reiterate, five goodness-of-fit statistics and indices were examined in order to assess the fit of the specified model to the study data. Of these, only the CMIN/*df* statistic (1.97) and RMSEA (0.07) indicated that the model fit was adequate. An obtained chi-square test statistic of 351.40 (df = 178, p = 0.000), a CFI of 0.88, and TLI of 0.86 suggested that the proposed model was less than satisfactory. Consequently, based on the totality of evidence, it was concluded that the posited model needed to be respecified in an attempt to improve its fit to the sample data.

SEM Path Analysis Model

As already mentioned, the adequacy of the measurement component of the original model seems to have been questionable. Therefore, as both the structural and measurement components of a model contribute towards its overall acceptability (Fabrigar & Wegener, 2014), an SEM path analysis approach was explored. An SEM path analysis model, a special application of SEM, involves structural relationships between observed or measured variables

(Klem, 2000). Therefore, unlike a full model, it does not include any unobserved variables or factors.

The process of modifying a structural equation model may include the removal of irrelevant parameters in order to simplify the proposed model (Klem, 2000). As the original SEM results showed that the parameter estimates linking running addiction and training load to URTI were nonsignificant, these linkages were removed. Similarly, training load did not predict running injury risk and was not directly related to perfectionism, Type A behaviour, or to either achievement goal orientation. As only the path between training load and running addiction was significant, no training load variables were included in the revised model.

The fit of a model may be improved by adding new linkages (Klem, 2000; Whittaker, 2012). Since a statistically significant correlation was found between task goal orientation and running addiction, and there is also some empirical support for this relation (Hall et al., 2007a), a directional path was added between these variables. The various structural paths leading from perfectionism (i.e., perfectionistic concerns, perfectionistic strivings, and parental perceptions), Type A behaviour, and ego goal orientation to running addiction, and from running addiction to running injuries were retained in the modified model. The injury indicator with the lowest factor loading (i.e., injury number) was, however, excluded.

SEM Path Analysis Model: Directional Relationships

Statistical analysis of the data showed that three of the six personality and motivation predictor variables exerted direct, positive effects on running addiction. These variables were perfectionistic concerns, Type A behaviour pattern, and task goal orientation. The strongest predictor of running addiction was perfectionistic concerns, followed by task goal orientation, and Type A behaviour pattern. It was found that running addiction, in turn, predicted injury history, injury duration, and injury-related training time loss. These results suggest that perfectionistic concerns, Type A behaviour, and task goal orientation may indirectly increase running injury risk through running addiction. However, the magnitude of all these effects was fairly small. The results indicate that ego goal orientation, perfectionistic strivings, and parental perceptions do not influence running addiction, which, in turn, is unrelated to injury severity.

Two of these findings were particularly noteworthy. The first of these discoveries concerned the impact of the different dimensions of perfectionism on running addiction. Contemporary researchers have proposed that a positive or adaptive and a negative or maladaptive form of perfectionism can be distinguished (Stoeber & Otto, 2006). The pursuit of high personal standards has been described as adaptive or healthy, whereas the self-critical dimension of perfectionism is viewed as maladaptive or unhealthy (Flett & Hewitt, 2002; Stoeber, 2014a). It is said that 'positive perfectionists', unlike 'negative perfectionists', have a flexible and realistic approach to achievement striving and are able to derive satisfaction from their efforts (Hagan & Hausenblas, 2003).

While the current findings do not support research suggesting that perfectionistic strivings represents an adaptive approach in sport and exercise (Appleton et al., 2009; Lemyre et al., 2003), it was shown that high personal standards did not contribute unique variance to the prediction of running addiction scores. Therefore, on the basis of these results, positive perfectionism does not seem to increase the risk for dysfunctional exercise behaviour in South African distance runners. In contrast, the dimension of perfectionistic concerns exerted independent positive effects on the outcome variable. Therefore, it seems that the self-critical facet of perfectionism, in comparison to the achievement striving dimension, is more likely to lead to negative outcomes in this population. The present results support the argument that when studying perfectionism in sport and exercise settings, it is important to control for the overlap between the positive and negative forms of the construct (Stoeber, 2014a).

The finding that perfectionistic concerns increased the risk for running addiction in this study is in line with earlier research attesting to the negative cognitive, affective, and behavioural correlates and consequences of this form of perfectionism in various populations (Achtziger & Bayer, 2013; Appleton et al., 2009; Lemyre et al., 2003; Molnar et al., 2006; Rice & van Arsdale, 2010; Stoeber & Rennert, 2008; Tashman et al., 2010). The results also support the observations of other researchers that maladaptive perfectionism influences running addiction risk (Hall et al., 2007a; 2007b; 2009). Since perfectionistic concerns has been positively associated with avoidance coping (Stoeber & Rennert, 2008), it is plausible that runners high in this dimension of perfectionism may have become dependent on exercise as means of coping with stress. Some investigators have also found that high personal standards positively predict unhealthy exercise patterns in runners (Hall et al., 2007a). However, in this particular study, a concern about making mistakes exerted a substantially stronger effect on the outcome variable in comparison with the personal standards dimension (Hall et al., 2007a). Consistent with the present results, parental expectations and parental criticism did not have independent effects on dysfunctional exercise behaviour in Hall et al.'s (2007a) investigation. Therefore, it seems that the facets of perfectionism that are related to perceptions of imposed parental standards of performance do not increase the risk of developing running addiction.

Another significant finding was that task goal orientation had a significant, positive effect on running addiction. Since this appears to be contrary to the tenets of achievement goal theory, this association was not originally predicted. However, this discovery supports the results of Hall et al.'s (2007a) study involving British distance runners. Therefore, it seems that task goal orientation may possibly be considered a risk factor for potentially maladaptive exercise patterns in runners.

The reason for this relationship is not immediately apparent, although one could speculate that it may be related to motivational processes. Theory and research suggests that task-involved individuals are prone to exert effort when performing tasks and also tend to persevere in the face of difficulties (Biddle et al., 2003; Roberts et al., 2007; Tenenbaum, et al., 2005). Furthermore, task goal orientation has been shown to predict higher levels of interest, enjoyment, and commitment in relation to tasks and activities (Conroy & Hyde, 2014). In most contexts, these emotions, cognitions, and behaviours are likely to be adaptive and should lead to positive outcomes. However, among individuals like runners who are presumably already quite highly motivated, these factors may perhaps foster a state of excessive achievement striving that may increase the risk for running addiction.

Additionally, Hall et al. (2007a) have stated that task goals may energize approach or avoidance behaviour, and striving to avoid incompetence may promote maladaptive exercise patterns. This argument seems valid when viewed from the behaviourist perspective that negative reinforcement underlies all addictive behaviours (Berczik et al., 2012). Although the achievement goal measure utilized in the present study assessed approach goals, a positive correlation has been found between the approach and avoidance dimensions of the mastery or task goal construct (Conroy et al., 2003). Therefore, some runners who strive for mastery or improvement, as indicated by high task goal scores in this study, may also endeavour to avoid incompetence, perhaps increasing their susceptibility to exercise addiction.

SEM Path Analysis Model: Nondirectional, Bivariate Relationships

Several bidirectional relationships in the model were statistically significant. As expected, significant intercorrelations were observed among perfectionistic strivings, perfectionistic concerns, and parental perceptions, and among the four running injury variables. Both perfectionistic strivings and perfectionistic concerns were also positively related to ego goal orientation, while the parental perceptions variable was negatively associated with task goal orientation.

The relationship observed between perfectionism and achievement goal orientations has some support in the literature. A study conducted in an educational setting adopting a hierarchical approach to the achievement goal construct showed that performance-approach goals (ego goals) were positively associated with both adaptive (high personal standards) and maladaptive (doubts about actions, concern over mistakes) dimensions of perfectionism (Vansteenkiste et al., 2010). It was also found that adaptive perfectionists pursued performance goals for autonomous or more self-determined reasons, such as challenge motives. Conversely, maladaptive perfectionism was associated with more controlled reasons, representing a lack of choice, for pursuing ego goals.

Positive correlations between ego goals and the perfectionistic concerns and perfectionistic strivings dimensions of perfectionism have also been documented in distance runners (Hall et al., 2007a). In the latter study, it was also reported that higher parental criticism scores were negatively related to task goal orientation, which was broadly consistent with the current findings. However, in Hall et al.'s (2007a) study, parental expectations was unrelated to the task goal construct.

The negative correlation found between parental perceptions and task goals in the current study may be due to possible contrasting reactions to failure associated with each construct. Achievement goal theory predicts that a task goal orientation is related to a positive attitude towards errors or failure (Elliott & Dweck, 1988). Given that skill acquisition or task mastery is the aim, task orientated people are likely to be unconcerned about making mistakes and may view setbacks as a means of developing competence (Elliott & Dweck, 1988). Research has confirmed these predictions (Elliott & Dweck, 1988). Conversely, the perfectionistic dimensions of parental expectations and criticism are likely to be associated with a negative response to failure or difficulties. These components of perfectionism reflect conditional parental love and approval. Therefore, a lack of success could mean parental rejection or the loss of love and acceptance (Frost et al., 1990).

Further positive correlations were found between task goal orientation and ego goal orientation, which replicates the original results, and between perfectionistic strivings and Type A behaviour pattern. The association between perfectionistic strivings and Type A behaviour is supported by theoretical assumptions that define both constructs in terms of excessive achievement aspirations (Flett et al., 1994; Frost et al., 1990; Lee et al., 1996).

SEM Path Analysis Model: Major Findings and Model Fit Assessment

It was found that the set of personality and motivation variables comprising parental perceptions, perfectionistic concerns, perfectionistic strivings, Type A behaviour, task goal orientation, and ego goal orientation explained 13% of the variance in running addiction in the path analysis model. This model accounted for between 1% and slightly more than 3% of the variability in each of the running injury variables. Consistent with the results yielded by the original SEM analysis, Type A behaviour exerted a direct positive effect on running addiction, which, in turn, had a significant positive impact on running injuries. It was also observed that higher task goal orientation was associated with a greater risk for running addiction. Of the perfectionism variables, only perfectionistic concerns had a statistically significant effect on dysfunctional running behaviour. As in the original model, however, the magnitude of these relationships was relatively small. Bivariate analyses showed that specific dimensions of perfectionism were significantly related to achievement goal orientations and Type A behaviour pattern.

An assessment of model fit revealed that the specified path analysis model was a reasonably good fit for the data. All five goodness-of-fit statistics and indices were within the recommended ranges (i.e., chi-square = 39.31, df = 31, p = 0.145; CMIN/df = 1.27; CFI = 0.98; TLI = 0.97; RMSEA = 0.03). This indicated that the SEM path analysis model should probably be accepted.

Modified SEM Path Analysis Model

While the SEM path analysis model was found to fit the data relatively well, it was plausible that removal of nonsignificant parameters and addition of new, potentially relevant linkages might enhance the fit. Therefore, a few revisions were made to the model in order to test this possibility. These changes included removing the structural paths linking parental perceptions, perfectionistic strivings, and ego goal orientation to running addiction, and running addiction to injury severity. Since running addiction was found to exert a significant effect on training load in the original structural equation model, a measure of training load was included in the modified model. Training workload (Volume × Intensity), which emerged as the best indicator of training load in the SEM measurement model (see Table 5.9), was selected for this purpose. The running injury variable, injury number, was also incorporated within the modified model. Consistent with the original research hypotheses, the revised model included directional paths linking task goal orientation and running addiction to training workload, and training workload to the running injury variables. Paths from perfectionistic concerns and Type A behaviour to training workload were not specified as separate correlational statistical analysis did not support these relationships. Task goal orientation and training workload were, however, significantly correlated (r = 0.19, p = 0.004).

Testing of the modified path analysis model revealed that, as expected, perfectionistic concerns, task goal orientation, and Type A behaviour pattern significantly predicted running addiction. In support of the original research hypotheses, and consistent with earlier analyses, it was found that running addiction, in turn, had a direct, positive impact on training workload. This suggests that perfectionistic concerns, task goal orientation, and Type A behaviour may indirectly affect training workload through running addiction. The structural path linking task goal orientation to training workload was nonsignificant. Therefore, task-involvement does not seem to have a direct effect on quantitative dimensions of exercise in this population. However, as discussed earlier, it is possible that task-oriented runners may generally have high levels of motivation, but the absolute amount of training performed may vary according to factors such as personal goals and running experience.

The results also showed that running addiction and training workload each contributed unique variance to the prediction of running injuries. However, the direction of these relationships differed. Whereas running addiction exerted a positive effect on running injuries, training workload had a negative impact on the outcome measures. Contrary to expectations, this implies that habitual heavy training may have a protective effect on running injury risk. More specifically, it seems that higher weekly training volume performed at a relatively high intensity may predict lower injury incidence.

The observation that running addiction and training workload have opposing physical health consequences supports the contention that the qualitative and quantitative dimensions of exercise are distinct constructs (Adkins & Keel, 2005). These findings also appear to counter the logical assumption that the adverse impact of running addiction on overuse injuries is mediated by excessive endurance training. On the contrary, as indicated, heavier training loads, in themselves, seem to be adaptive. Therefore, the harmful effects of running addiction may be due primarily to chronic, dysfunctional training-related behaviours and increased psychosocial stress that may independently or in combination increase the risk for training maladaptations and thus, overuse injuries.

The finding that higher training workload levels were associated with lower running injury scores seems to contradict theoretical approaches implying that chronic training-related stress increases the risk for adverse physical health outcomes (Appaneal & Perna, 2014; Nieman, 2001; Selye, 1975). It is also inconsistent with research that has reported a positive association between training volume and overuse injuries (Diekhoff, 1984; Huxley et al., 2014; Layman & Morris, 1991; Nielsen et al., 2012; Ryan et al., 2006; van Gent et al., 2007; van Middelkoop et al., 2008). Nevertheless, the results support studies that have demonstrated an inverse relationship between these variables (Fields et al., 1990; van Gent et al., 2007; van Poppel et al., 2015). For example, it was found that the risk of sustaining an injury was significantly higher in club runners averaging less than 32 kilometres per week compared with those running more than 64 kilometres per week (Fields et al., 1990). According to a systematic review of the literature, there is also strong evidence that increasing weekly training volume is protective against knee injuries in runners (van Gent et al., 2007). Few studies have assessed the effects of training intensity, or perceived exertion, on running injury risk. However, there is evidence that regular interval training (alternating bursts of fast and slow running in a single session) is associated with a reduced incidence of running injuries (van Middelkoop et al., 2008; van Poppel et al., 2015).

It has been proposed that training variables may interact with one another to influence running injury risk (Nielsen et al., 2012). However, this possibility has generally not been considered in previous research. Thus, by employing a measure of training workload that assessed the combined effects of training volume and intensity on running injuries, the current study appears to differ from many earlier investigations. Based on the present results and previous research findings concerning the potential benefits of interval training (van Middelkoop et al., 2008; van Poppel et al., 2015), it is plausible that habitual high volume, high intensity training may promote superior physical fitness and conditioning. According to van Gent et al. (2007), running injuries may be a result of either overuse or under-conditioning. This suggests that enhanced physical conditioning may provide a measure of protection against overuse injuries.

One can also speculate that individuals who regularly train at high levels may be more serious about running and more scientific about their training. For instance, these runners may be more likely to adhere to well-established training principles that are aimed at minimizing training maladaptations and injury occurrences. They may also be more likely to heed symptoms of fatigue indicating that rest rather than further hard training is required. Additionally, these individuals may tend to seek medical advice or treatment at the first sign of injury and adjust their training accordingly. These factors may individually or collectively explain the inverse relationship between training workload and running injuries found in this study.

Modified Path Analysis Model: Major Findings and Model Fit Assessment

The set of variables comprising perfectionistic concerns, Type A behaviour pattern, and task goal orientation was found to explain 12% of the variance in running addiction scores. The model also accounted for 9% of the variance in training workload, 6% of the variability in injury history, 5% of the variability in injury number and injury-related training time loss, and 4% of the variance in injury duration. One of the major findings in relation to the revised path analysis model was that training workload exerted a significant, negative effect on running injuries. Consistent with the results yielded by previous analyses, perfectionistic concerns, Type A behaviour pattern, and task goal orientation had direct, positive effects on running addiction, which, in turn, increased the risk of experiencing running injuries. Higher levels of running addiction also predicted higher training workload scores.

The various fit statistics and indices computed for the revised path analysis model indicated that this model was a satisfactory fit for the sample data (chi-square = 24.51, *df* = 14, p = 0.04; CMIN/*df* = 1.75; CFI = 0.95; TLI = 0.88; RMSEA = 0.06). Although the fit of the initial path analysis model seemed to be slightly superior, the modified model arguably has greater theoretical and practical significance. One of the reasons for this is that the revised model was able to explain a larger proportion of the variance in running injury scores compared to the original path analysis model. It was also able to show that exercise addiction and training load each have different outcomes and thus are separate yet related entities.

In the final chapter, the major conclusions reached in this study will be presented and discussed. The contribution that this study could make towards understanding physical and psychological health risks in distance runners, and the potential practical applications of this knowledge, will be considered as well. Limitations of the study will also be addressed, and recommendations for future research will be provided.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

This final chapter has four primary objectives. These are (1) to present and discuss major findings and conclusions relevant to this investigation, (2) to describe limitations of the research, (3) to consider potential contributions and applications of the study, and (4) to provide recommendations for future research. For orientation and clarity purposes, this section will begin by reminding the reader of the background to the research problem, the aims of the study, the research hypotheses, and various methodological issues.

Background to the Research Problem

Distance running has become a popular participation sport in South Africa. Considering its affordability, accessibility, and numerous rewards, the pastime's growing appeal among all sectors of the population can be appreciated. These benefits include markedly improved physical fitness and conditioning, a significantly lower risk of serious diseases, increased self-esteem, self-concept, and self-efficacy, and enhanced psychological well-being (Dubbert, 2002; Khatri & Blumenthal, 2007; Landolfi, 2012). Running also provides opportunities for social interaction, friendship, and personal challenge while promoting a sense of mastery and achievement.

In general, therefore, distance runners may enjoy higher-than-average levels of physical health and psychological well-being. For some individuals, however, a traditionally healthy and rewarding activity may develop into self-destructive and self-defeating behaviour. An obsessional approach and a perceived loss of control over exercise suggest that one's involvement has shifted from beneficial to detrimental (Berczik et al., 2012; Terry et al., 2004). When this occurs, all the classic symptoms of a behavioural addiction may be present (Berczik et al., 2012; Khatri & Blumenthal, 2007; Downs & Hausenblas, 2014). These include the symptoms of salience, withdrawal effects, increased tolerance, mood modification, social conflict, and relapse (Terry et al., 2004). This condition, which can be labelled exercise or running addiction, is likely to have wide-ranging adverse social, psychological, and physical consequences (Adams, 2009; Allegre et al., 2006; Berczik et al., 2012; de Coverley Veale, 1987; Downs & Hausenblas, 2014; Gapin et al., 2009; Hausenblas & Giacobbi, 2004; Khatri & Blumenthal, 2007; Landolfi, 2012; Terry et al., 2004).

Theories and models that focus on the nature and outcomes of the body's physiological reactions to physical and/or psychosocial stressors (Appaneal & Perna, 2014; Nieman, 2001; Selye, 1975) imply that running addiction and/or prolonged heavy training may increase susceptibility to musculoskeletal injuries and upper respiratory tract infections (URTIs). Running injuries have been described as a common hazard of the sport (Noakes, 2001). In support of this view, a recent study reported an annual injury prevalence of 90% among South African distance runners (Ellapen et al., 2013). Injuries may, in turn, have a negative impact on psychological well-being (Allegre et al., 2006; Berczik et al., 2012; Noakes & Granger, 2003; Pittsinger et al., 2013; Wiese-Bjornstal, 2010), impede training and performance (Grisogono, 1994), and increase the risk of developing future degenerative conditions (Finnoff, 2012). Similarly, URTIs may adversely affect health-related quality of life (Linder & Singer, 2003), impair the capacity for training and competition (Nieman, 2001), and occasionally lead to serious health complications (Noakes, 2001; Shephard & Shek, 1999).

While a number of scholars have warned of the negative physical health consequences of compulsive forms of exercise engagement (Allegre et al., 2006; Berczik et al., 2012; Hausenblas & Downs, 2002b; Hagan & Hausenblas, 2003; Hays, 2004; Khatri & Blumenthal, 2007; Landolfi, 2012; Terry et al., 2004), few have empirically examined these ideas. Therefore, little is known about the effects of exercise addiction on overuse injury and URTI risk in a running population. There is also limited understanding of the factors that underlie potentially harmful exercise behaviour (Hall et al., 2009), especially in South African distance runners. Moreover, despite a wealth of research, it seems that the influence of quantitative dimensions of exercise behaviour on injuries and URTIs in runners is still not clear.

Objectives of the Current Study

In view of the potential deleterious effects of running addiction, overuse injuries, and URTIs, knowledge of the precursors of these disorders may be important in helping runners to stay psychologically and physically healthy. It may also allow this group of individuals to maximize the diverse physical, psychological, and social benefits afforded by the sport. Similarly, since training factors may affect injury and URTI risk, an awareness of psychological influences on training load may have practical health implications. Therefore, the key objectives of the present study were to investigate the following relationships in South African distance runners:

- The impact of perfectionism, Type A behaviour pattern, and achievement goal orientations on running addiction risk and customary training load;

- The effects of running addiction and training load on self-reported upper respiratory tract infections and running injuries.

Research Hypotheses and Methodological Issues

A number of research hypotheses, derived from theory and based on the research literature, were formulated. Collectively, these predictions represented the broad expectation that certain personality and motivation variables underlie potentially harmful aspects of exercise behaviour, which, in turn, influence specific physical health problems in South African distance runners. The primary research hypotheses were as follows:

- Perfectionism, Type A behaviour pattern, and ego goal orientation have direct, positive effects on running addiction risk.

- Perfectionism, Type A behaviour pattern, ego goal orientation, task goal orientation, and running addiction have direct, positive effects on training load.

- Running addiction and training load have direct, positive effects on running injuries and URTIs.

The research sample in this study was composed of 220 South African distance runners who belonged to 29 different running clubs situated across the country. Participants completed an online survey, the link to which had been emailed to the relevant club official with a covering letter requesting assistance with the research. A directory of athletic clubs had been obtained from a well-known South African road running website (i.e., http://www.runnersguide.co.za). A total of 60 clubs with their own websites had been selected from this list.

Various psychometrically-validated questionnaires were used to assess the constructs of perfectionism, Type A behaviour pattern, achievement goal orientations, and running addiction. The variables of training load, running injuries, and upper respiratory tract infections were measured mainly using a self-report checklist approach. Various short rating scales, constructed by the author, were also used to assess certain dimensions of the latter factors.

The network of predicted associations among the study variables was analysed using the sophisticated multivariate statistical technique of structural equation modelling (SEM). Combining the statistical methods of path analysis and confirmatory factor analysis, SEM allows one simultaneously to test the direct and indirect effects of the independent variables on the dependent variables, the bivariate interrelationships among predictor and/or outcome variables, and the effects of factors on their respective indicators in the measurement component of the specified model.

In the proposed structural equation model, three indicators (i.e., perfectionistic concerns, perfectionistic strivings, and parental perfections) were used to create the latent variable of perfectionism, while the training load factor was represented by four measured variables (i.e., training workload, training frequency, competition frequency, and underrecovery). Five variables were selected as indicators of the unmeasured variables, URTIs and running injuries, respectively (i.e., URTI/injury number, URTI/injury severity, URTI/injury duration, URTI/injury-related training time loss, and URTI/injury history).

Testing of the original full structural equation model revealed that it was an inadequate fit for the sample data. Therefore, the initial model was modified and a path analysis model, consisting of measured variables only, was specified and tested. Although this model fit the data relatively well, this too was revised in order to determine whether the fit could be improved. The final model tested was also found to be a good fit for the data. Therefore, two of the proposed models were acceptable, providing support for the psychological basis of potentially harmful exercise behaviour and its effects, in turn, on various physical health parameters in distance runners.

Major Findings and Conclusions

Prevalence of Running Addiction

Among the key findings of this study were that a fairly large proportion of the runners in this sample (16.8%) can be classified as being at risk for running addiction. This discovery supports Hall et al.'s (2009) assertion that exercise addiction is more prevalent among strongly committed exercisers compared with the general population. In real terms, the results of this research suggest, for example, that in a distance running event with 20 000 finishers (e.g., the Comrades Marathon), 1 200 participants may be vulnerable to the disorder. Consistent with previous studies, it seems that female endurance athletes are more susceptible to exercise addiction compared with male athletes. It should be noted that questionnaire-based assessments of exercise addiction are merely screening tools, and clinical assessment is needed for a definitive diagnosis (Berczik et al., 2012; Egorov & Szabo, 2013). Even so, the current findings indicate that exercise addiction could be a significant problem among South African distance runners.

Prevalence of Running Injuries and URTIs

An overwhelming majority of participants (90%) reported experiencing an overuse injury during the preceding three-month period. This substantiates the view that running injuries are a hazard of the sport (Noakes, 2001). However, operationally defining injuries as running-related pain may have inflated this figure to some degree. More than half of the sample (57%) also experienced injury-related training stoppages during this time. Therefore, it seems that many participants in this study had recently sustained a non-trivial running injury. A fairly large percentage of the research sample (47%) also reported suffering from an upper respiratory tract infection, such as the common cold, influenza, cough, or sore throat, during the previous three months. Infectious episodes had also led to training disruptions in almost 40% of study participants. This shows that viral infections had recently had an adverse impact on many runners in this study. However, self-reported URTI occurrence in this group seemed to largely agree with previously-reported estimates in similar individuals. Also, the results of this investigation suggest that running injuries pose a greater health threat to South African runners relative to upper respiratory tract infections.

Psychological Predictors of Running Addiction

The findings of this study indicate that, consistent with expectations, personality and motivational variables may increase the risk for exercise addiction among South African distance runners. Therefore, as there is evidence that running addiction increases susceptibility to overuse injuries, these psychological factors may have indirect implications for physical health outcomes in distance runners.

First, the results show that perfectionism may predispose this population to develop an obsession with exercise. This confirms the findings of previous research involving distance runners conducted in other countries (Hall et al., 2007a; 2007b; 2009). The results also support the view that perfectionism is maladaptive in various life domains (Hewitt & Flett, 2002; Lombardi et al., 1998), including in sport and exercise settings (Flett & Hewitt, 2005).

It seems, however, that the self-critical dimension of perfectionism (i.e., the variable, perfectionistic concerns) primarily accounts for the adverse effects of this disposition on running addiction. This dimension of the construct is characterized by heightened concerns about producing a less than flawless performance, and a lingering sense of inadequacy about the quality of one's performance (Frost et al., 1990). The perfectionistic strivings dimension of perfectionism, which is related to the setting of high personal standards, does not appear to have an independent effect on susceptibility to running addiction. Similarly, it seems that perceptions that one's parents were overly critical or expected very high standards of performance are not adverse, in isolation, in the context of exercise addiction risk.

The discovery that the different dimensions of perfectionism have dissimilar effects on pathological exercise behaviour is broadly consistent with a dual conception of the construct. According to this perspective, perfectionistic concerns are maladaptive, while perfectionistic strivings predict adaptive emotions, cognitions, and behaviours (Flett & Hewitt, 2002; Stoeber & Otto, 2006; Stoeber, 2014a). However, one could argue that, when considered separately, the achievement striving dimension of perfectionism merely reflects the trait of conscientiousness (Flett & Hewitt, 2002).

The results of this investigation also demonstrate that Type A behaviour may be a risk factor for running addiction among South African athletic club members. This finding is consistent with the view that Type A behaviour pattern can be maladaptive (Lee et al., 1993; Martin et al., 1989; Sogaard et al., 2008; Ward & Eisler, 1987). This disposition has traditionally been dubbed, "a coronary-prone behaviour pattern" (Burnman et al., 1975, p. 76) and has also been positively linked to running injury incidence (Diekhoff, 1984; Ekenman et al., 2001; Fields et al., 1990). However, it seems that the negative effects of this trait are not limited to the realm of physical health. Instead, there is now evidence that the Type A combination of intense achievement striving, impatience, time urgency, and anger/hostility may increase the risk for pathological exercise behaviour.

The factors mediating the effects of perfectionism and Type A behaviour on running addiction were not assessed in this study. However, based on theories highlighting the role of stress and coping in the onset and maintenance of exercise addiction (Egorov & Szabo, 2013), it is conceivable that perceived stress could be an intervening factor in this relationship. Due to their unrealistically high goals and ineffective coping strategies (Frost et al., 1990; Hewitt & Flett, 2002), runners who are high in perfectionism and/or Type A behaviour may tend to experience higher levels of training and non-training stress. Since these individuals are already aware of the mood modifying benefits of aerobic exercise, running may be employed as a means of managing increasingly intolerable stress. Once exercise has been established as a coping mechanism, the vulnerability to addiction may be increased (Berczik et al., 2012; Egorov & Szabo, 2013). Also, perfectionists and Type As are generally over-concerned with self-validation and failure avoidance and are unable to recognize personal limits (Ellis, 2002; Flett & Hewitt, 2002; Hall et al., 2007a; 2009; Martin et al., 1989). These tendencies may foster maladaptive achievement striving, which could increase the risk for compulsive exercise behaviour (Egorov & Szabo, 2013).

Additionally, this study found evidence that a task goal orientation may increase the risk for running addiction, which confirms the findings of a previous study involving British runners (Hall et al., 2007a). Despite the apparent growing support for this relationship, the reason for this association remains unclear. One can speculate that certain motivational factors may mediate this relationship. Also, task-involved runners who strive to avoid incompetence may be more susceptible to exercise addiction (Hall et al., 2007a) as, according to behaviourists, negative reinforcement underlies all addictive behaviours (Berczik et al., 2012).

While task orientation appears to have implications for running addiction risk, ego goal orientation does not seem to increase runners' susceptibility to potentially harmful exercise behaviour. This suggests that endorsing ego goals is not necessarily maladaptive, and that the motivational and behavioural consequences of this orientation may depend on factors such as the athlete's perceived ability (Hall et al., 2007a; Roberts et al., 2007; Tenenbaum et al., 2005).

In conclusion, although perfectionism, Type A behaviour, and task goal orientation appear to contribute towards the prediction of pathological exercise behaviour in South African runners, it seems that these factors only account for a small proportion of the variance in running addiction risk. Therefore, a multitude of other factors may potentially influence a distance runner's susceptibility to exercise addiction. Based on the tenets of Egorov and Szabo's (2013) interactional model of exercise addiction, a complex set of variables, including personality, goals, interests, needs, social values, exercise accessibility, social setting, exercise-related motives, and life-event stress may interact to influence the risk for running addiction.

Psychological Predictors of Training Load

Contrary to expectations, the research results suggest that the personality and motivational dispositions that were assessed in this study do not exert direct effects on South African runners' training habits. Therefore, it appears that perfectionism, Type A behaviour, and task goal orientation influence pathological rather than more adaptive exercise behaviours, or qualitative as opposed to quantitative dimensions of training. It is possible, though, that the influence of these factors on absolute training load may depend on factors such as personal goals and running experience. Further investigation may help to explain the present findings.

Effects of Running Addiction and Training Load on Injury Risk

Aside from the general destructiveness of addiction, the findings of this study suggest that higher running addiction risk may increase susceptibility to overuse injuries in South African distance runners. Although these effect sizes were small, the possibility that an underlying psychological disorder may affect injury risk may provide a new dimension to the understanding, prevention, and treatment of running injuries in this population. It is conceivable that a dysfunctional approach to exercise may increase the likelihood of experiencing physical and psychosocial stress and consequently, training maladaptations (e.g., the overtraining syndrome) and overuse injuries.

In contrast, the results of the SEM path analysis indicate that training workload, a composite measure of training volume and training intensity (i.e., perceived exertion), is inversely related to running injury risk in South African runners. This raises the possibility that routine heavy endurance training may promote superior physical conditioning, which may have a protective effect against injury occurrences. It also suggests that operationally defining running addiction in terms of exercise amount, as some studies have done, may be inappropriate as these phenomena appear to represent two distinct, albeit related dimensions of exercise behaviour (Adkins & Keel, 2005; Meyer & Taranis, 2011). Significantly, this study has shown that qualitative and quantitative aspects of exercise behaviour in runners may have opposing physical health consequences.

In conclusion, these findings imply that running addiction may perhaps promote dysfunctional training-related behaviours that could potentially increase both physical and psychosocial stress, thus elevating the risk for overuse injuries. Conversely, high-volume training performed at a relatively high level of intensity may be protective against injuries, possibly due to the athlete's enhanced physical conditioning. Despite these observations, it appears that exercise behavioural factors only explain a small amount of the variance in running injury susceptibility. Thus, it is probable that a combination of biological, psychological, physical environmental and sociocultural factors influence overuse injury risk in South African distance runners (Wiese-Bjornstal, 2010).

Effects of Running Addiction and Training Load on URTI Risk

Contrary to predictions, the findings of this research suggest that neither running addiction nor training load influence susceptibility to upper respiratory tract infections in South African athletic club members. Various factors could explain these results. For example, it is possible that runners who generally adopt heavy training loads may have habituated to the stress of intense training and competition, reducing the risk of exercise-induced immunosuppression. Also, individual factors such as nutritional status, genetic predispositions, and fitness levels may potentially moderate the relationship between exercise and infection (Moreira et al., 2009). Further research may help to account for the current findings.

Limitations of the Study

The present study may have several methodological limitations, which implies that the research findings may need to be interpreted with caution.

First, it is evident that the use of a self-report methodology may yield unreliable data. For example, retrospective self-reports may be prone to response bias as a result of recall difficulties or due to the tendency to over-report socially desirable behaviours and under-report undesirable behaviours (Fife-Schaw, 1998). Similarly, self-report psychometric questionnaires may produce inaccurate responses when individuals attempt to portray a positive image of themselves (Hammond, 1998). Further, individual difference factors, such as neuroticism and optimism, may influence self-reports (Jones & Kinman, 2001). For instance, people high in neuroticism may over-report illness and injury occurrences, whereas optimists may under-report such events. Additionally, the use of self-report techniques to assess both stressors (e.g., running addiction and training load) and strains (e.g., overuse injuries and URTIs) may lead to the problem of method variance (Jones & Kinman, 2001). This means that any observed relationship between the constructs of interest may be a function of the method of data collection.

Moreover, the use of a convenience sample may limit the generalizability of the research findings. Also, the use of an online survey to collect the data may have resulted in a research sample that was more sophisticated and/or belonged to a higher socioeconomic bracket than the average South African runner. Therefore, the current group may not be truly representative of the South African distance running population at large. It is also unclear whether the present results can be generalized to running populations in nations that differ in terms of culture, nationality, environment, language, and so on.

There is also the issue of linearity to consider. Linearity is a common assumption in many bivariate and multivariate tests that was not specifically evaluated in this study but, if violated, can influence the study results (Rovai et al., 2014). Linearity refers to the assumption that the relationship between two continuous variables approximates a straight line (Rovai et al., 2014). Linearity can be assessed through the use of statistical methods; by referring to theory and previous research; or by the use of graphical methods, which includes examining scatterplots and residual plots (Rovai et al., 2014). Detecting nonlinearity simply by inspecting scatterplots can sometimes be difficult, however (Rovai et al., 2014). When the assumption of linearity is violated, a statistical test may fail to find a relationship between two variables or may underestimate the strength of a relationship (Rovai et al., 2014).

A further issue to bear in mind when interpreting the study results is multicollinearity. This phenomenon occurs when two or more predictor variables in multiple regression analyses are very highly correlated ($r \geq 0.90$), and one or more variables are therefore redundant (Rovai et al., 2014). According to Marsh (2007), multicollinearity can render parameter estimates misleading or difficult to interpret. There are a number of ways to assess multicollinearity, and it has been recommended that where bivariate correlations exceed 0.70, variables should be removed from the analysis (Rovai et al., 2014). Although none of the bivariate correlations between the predictor variables in the present study were above this threshold – the highest correlation was 0.52, between perfectionistic strivings and perfectionistic concerns – multicollinearity could still be a problem.

Finally, as this study employed a nonexperimental, correlational design, one is precluded from drawing definitive conclusions about cause and effect relationships. In this regard, Marsh (2007) has cautioned that "just because a causal model is able to fit the data does not imply that assumptions of causality underlying the model have been proved – only that the data are consistent with the model" (p. 779). Therefore, the present results show only that the variables covary and not that one variable 'causes' another, despite assumptions to this effect. In order to establish causality, three conditions must hold: (1) the variables must be significantly related, (2) the predictor variable must occur before the outcome variable, and (3) plausible competing explanations for the observed relationship must have been excluded (Rosnow & Rosenthal, 1996).

In the present study, only the first criterion for causality was satisfied. Since the research design was retrospective, which means that the independent and dependent variables were assessed simultaneously, the temporal ordering of events could not be established with certainty. Therefore, the second condition for determining causality was not met. For instance, the discovery that training workload was negatively related to running injury risk could indicate that either heavier endurance training enhances resistance to overuse injuries, or that lower injury incidence allows runners to train harder. Likewise, a positive relationship between task goal orientation and running addiction could mean that either task goal orientation increases running addiction risk, or that the latter promotes a greater focus on task mastery and improvement. Similarly, while it is more probable that exercise addiction leads to overuse injuries, rather than vice versa, the latter possibility cannot be ruled out.

Contributions and Applications of the Study

Despite the methodological limitations described above, the present study may help to promote insight into health risks of distance running that could adversely affect physical, psychological, and social functioning. In particular, this research may succeed in increasing current awareness of exercise addiction risk in South African distance runners. The study may help to facilitate understanding of the factors underlying this disorder, as well as its impact on running injuries, another peril of the sport. To date, there has been a paucity of empirical research examining the psychological antecedents of exercise addiction or its physical health consequences in endurance athletes. Studies conducted in South Africa are especially scarce. Therefore, the present investigation may add to both international and domestic bodies of knowledge pertaining to issues of endurance athlete health. This undertaking may also help to illuminate the relationship between psychological and physical health in sport and exercise settings.

Additionally, this investigation may increase insight into the impact of training load on running injury risk. The observation that high volume, high intensity training may reduce runners' susceptibility to injuries provides an interesting perspective to this field of study that could provide the basis for further enquiry. This effect was also in the opposite direction to that documented for running addiction. This implies that the latter construct should not be conceptualized in terms of quantitative aspects of exercise behaviour.

This study may also contribute towards the perfectionism, Type A behaviour, and achievement goal literature, enhancing present understanding of these constructs. For example, this enquiry corroborates previous research attesting to the adverse effects of maladaptive perfectionism on psychological health and well-being in athletes and non-athletes (Achtziger & Bayer, 2013; Appleton et al., 2009; Hall et al., 2007a; 2007b; 2009;

Lemyre et al., 2003; Molnar et al., 2006; Rice & van Arsdale, 2010; Stoeber & Rennert, 2008; Taranis & Meyer, 2010; Tashman et al., 2010). Further, the current research indicates that Type A behaviour pattern may be a risk factor for running addiction, which seems to be a previously unexplored consequence of this personality trait. The discovery that task goal orientation may predict increased susceptibility to pathological exercise behaviour is significant as well because achievement goal theory predicts that task goals are primarily adaptive (Elliott & Dweck, 1988; Roberts et al., 2007; Tenenbaum et al., 2005).

Finally, the findings of this investigation may have several practical implications for the health and well-being of South African distance runners. For example, the results highlight the need to educate health care practitioners, athletic coaches, and distance runners and their family members on the dangers of an obsessive approach to exercise. By enhancing awareness of the prevalence of running addiction and its characteristic signs and symptoms, appropriate and timeous interventions may be implemented. Apart from displaying the various classic features of behavioural addiction, at-risk runners may present with recurrent overuse injuries. These individuals may also display perfectionistic and Type A tendencies, such as intense achievement striving and an over-concern with failure. Further, susceptible runners may be highly task-oriented, continually striving to improve their race times and/or conquer increasingly longer distances. Many runners with these characteristics, however, are unlikely to be addicted to exercise. Still, those runners who appear to be vulnerable to exercise addiction should be encouraged to seek professional help or, at the very least, to reassess their priorities and to participate in other activities in order to create more balance in their lives (Grisogono, 1994).

Recommendations for Future Research

Various recommendations for future research can be proposed. These suggestions relate to research design and methodological issues as well as to aspects of the research problem that seem to merit additional investigation.

First, due to limited knowledge of the psychological antecedents and physical health consequences of exercise addiction in South African runners, further research is required to confirm the present findings. It is also advised that future studies utilize larger research samples that are more representative of the South African distance running population. This may serve to enhance the generalizability of the results.

Second, future investigations could consider exploring the psychological moderators and mediators of the personality/motivation–exercise behaviour relationship. A moderator alters the nature of the relationship between two variables, affecting either its strength or direction. A mediating factor is a variable that intervenes between the independent and dependent variables and serves as the mechanism whereby one variable affects another (Cooper & Bright, 2001). Forthcoming studies could, for example, attempt to ascertain whether stress and/or maladaptive cognitions mediate the effects of perfectionism and Type A behaviour on running addiction. Likewise, identifying the mediating mechanisms in the relationship between task goal orientation and exercise addiction could help to clarify this association. It could also be beneficial to know whether factors like running experience moderate the influence of personality and motivational variables on training load. Similarly, future studies could test the hypothesis that perceived ability influences the relationship between ego goal orientation and maladaptive exercise behaviour.

Third, identifying the psychological/physiological and/or behavioural mediators of the running addiction–running injury relationship may help to increase insight into these disorders. Further research is also required in order to investigate whether physical conditioning factors perhaps explain the inverse relationship that was observed between training workload and running injuries in this study. Additionally, potential moderators of the exercise behaviour–injury/URTI relationship could warrant examination. Investigators could, for example, aim to determine whether factors like age and biomechanics influence the impact of training load on overuse injuries and whether a variable like nutritional status affects the association between training levels and URTI risk.

Fourth, it is recommended that future studies exploring the motivational antecedents of potentially harmful exercise behaviour adopt a hierarchical approach to the assessment of the achievement goal construct. This model conceptualizes achievement goals not only in terms of the manner in which competence is defined but according to whether the aim of achievement behaviour is to attain a positive, desirable outcome or to avoid a negative, undesirable outcome (Elliot & Thrash, 2001). Goals that involve striving for competence are called approach goals, whereas those that involve striving away from incompetence are called avoidance goals. Four kinds of achievement goals can thus be distinguished: mastery-approach, performance-approach, mastery-avoidance and performance-avoidance (Elliot & Thrash, 2001). It has been posited that mastery-approach goals are typically adaptive, while performance-avoidance goals are mostly dysfunctional. Performance approach and mastery-avoidance goals are expected to produce mixed outcomes (Conroy & Hyde, 2014; Roberts et al., 2007). Since behaviourists contend that negative reinforcement underlies addiction (Berczik et al., 2012), it may be important to establish the effects of an avoidance orientation on the risk of pathological exercise behaviour.

Fifth, prospective or longitudinal designs in which participants are assessed on two or more occasions are needed to elucidate the precursors of exercise addiction, overuse injuries, and upper respiratory infections. In the proposed investigations, the predictor variables could be measured at start of the study and the outcome variables, such as injuries and URTIs, assessed over the course of the research or at the end of the study. Prospective designs allow one to determine the temporal ordering of events, which may enhance the accuracy of subsequent conclusions (Petrie & Falkstein, 1998). For example, employing such an approach may help to determine whether training workload is an antecedent or consequent of running injury incidence or whether task goal orientation affects, or is affected by running addiction.

Sixth, future studies could consider exploring the impact of training factors on overuse injury and infectious illness risk using an experimental approach. For example, a group of runners could be randomly assigned to two groups which are then differentially exposed to an exercise intervention. After a designated period, the injury and URTI incidence of each group could be compared in order to determine whether the exercise intervention had any effect.

Seventh, instead of relying on self-reports, it is advised that, where practical, researchers employ more objective methods, such as physician ratings, to assess running-related physical health outcomes. This should yield more reliable data. If this is not feasible, then the use of a diary technique to collect training and health data may help to enhance the accuracy of self-reports. Alternatively, researchers could analyse participants' medical records and/or logbooks in order to elicit the required information. Similarly, investigators might consider utilizing clinical diagnosis to assess the condition of exercise addiction since questionnaires only serve as surface screening tools (Berczik et al., 2012; Egorov & Szabo, 2013).

Concluding Remarks

This study set out to investigate the psychological and physical health risks of distance running using the multivariate statistical technique of structural equation modelling. While endurance exercise is generally beneficial, the findings of this research suggest that running injuries are common among South African distance runners. Also, a meaningful percentage of this population may be at risk for running addiction. Further, the results of this study suggest that certain personality and motivational factors – specifically perfectionism, Type A behaviour, and task goal orientation – influence running addiction risk, which, in turn, increases overuse injury incidence. In contrast, the findings indicate that training workload is inversely related to injury risk, while neither running addiction nor training load influence URTI susceptibility in South African runners. This study may contribute towards a greater understanding of health risks associated with distance running, which may, in turn, have practical implications for the long-term health and well-being of this population.

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APPENDICES

Appendix A: The Study Questionnaire

This survey forms part of a UNISA doctoral study on personality and training influences on running injuries and upper respiratory infections in South African distance runners.

The results may suggest new ways to promote health and well-being among runners of all abilities.

Although we know your time is precious, we sincerely hope you might be able to spare about 15 minutes to complete the survey. Your contribution would be of immense value and interest to us. Also, all participants stand a chance to receive a pair of running shoes of their choice to the value of R1,200.00.

Before proceeding, please note the following:

- Participation is open to all running club members aged 18 and older who take part in official races (road, track or cross country) of any distance (from 800 metres upwards).

- Participation is voluntary and you may choose not to participate, or may withdraw your consent and decline to participate at any stage.

- All responses shall remain strictly confidential.

- The results may be published in an accredited journal and the findings will be made available to all interested participants. However, all respondents shall remain anonymous in these and any other printed work.

- The survey should take approximately 15 - 20 minutes to complete.

- Please complete the survey once only.

If possible, kindly complete the survey by 04 November, 2013.

For queries, please contact gstruwig@fastener-network.co.za or call 072-149-1879.

Thank you for your cooperation and participation!

1. Consent to Participate

I understand the purpose of this survey, and that participation is voluntary. I am also aware that all information collected shall be treated as confidential, and that all respondents shall remain anonymous.

Please select the relevant button below:

	Yes	**No**
I hereby agree to participate in this survey	●	○

2. What does success in sport mean to you? There are no right or wrong answers. For each statement, please choose the option that best indicates how you feel.

When playing sport, I feel most successful when:

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I beat other people.	●	●	●	●	●
I am clearly superior.	●	●	●	●	●
I am the best.	●	●	●	●	●
I work hard.	●	●	●	●	●
I show clear personal improvement.	●	●	●	●	●
I outperform my opponents.	●	●	●	●	●
I reach a goal.	●	●	●	●	●
I overcome difficulties.	●	●	●	●	●
I reach personal goals.	●	●	●	●	●
I win.	●	●	●	●	●
I show other people I am the best.	●	●	●	●	●
I perform to the best of my ability.	●	●	●	●	●

3. Below are various statements concerning your preferences and opinions about several things. For each statement, please choose the option that best reflects how you feel.

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
My parents set very high standards for me.	●	●	●	●	●
Organisation is very important to me.	●	●	●	●	●
As a child, I was punished for doing things less than perfect.	●	●	●	●	●

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
If I do not set the highest standards for myself, I am likely to end up a second-rate person.	●	●	●	●	●
My parents never tried to understand my mistakes.	●	●	●	●	●
It is important to me that I be thoroughly competent in everything I do.	●	●	●	●	●
I am a neat person.	●	●	●	●	●
I try to be an organised person.	●	●	●	●	●
If I fail at work/school, I am a failure as a person.	●	●	●	●	●
I should be upset if I make a mistake.	●	●	●	●	●
My parents wanted me to be the best at everything.	●	●	●	●	●
I set higher goals than most people.	●	●	●	●	●
If someone does a task at work/school better than I, then I feel like I failed the whole task.	●	●	●	●	●
If I fail partly, it is as bad as being a complete failure.	●	●	●	●	●
Only outstanding performance is good enough in my family.	●	●	●	●	●
I am very good at focusing my efforts on attaining a goal.	●	●	●	●	●

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
Even when I do something very carefully, I often feel that it is not quite right.	●	●	●	●	●
I hate being less than the best at things.	●	●	●	●	●
I have extremely high goals.	●	●	●	●	●
My parents have expected excellence from me.	●	●	●	●	●
People will often think less of me if I make a mistake.	●	●	●	●	●
I never felt like I could meet my parents' expectations.	●	●	●	●	●
If I do not do as well as other people, it means I am an inferior human being.	●	●	●	●	●
Other people seem to expect lower standards from themselves than I do.	●	●	●	●	●
If I do not do well all the time, people will not respect me.	●	●	●	●	●
My parents have always had higher expectations for my future than I have.	●	●	●	●	●
I try to be a neat person.	●	●	●	●	●
I usually have doubts about the simple everyday things I do.	●	●	●	●	●

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
Neatness is very important to me.	●	●	●	●	●
I expect higher performance in my daily tasks than most people.	●	●	●	●	●
I am an organised person.	●	●	●	●	●
I tend to get behind in my work because I repeat things over and over.	●	●	●	●	●
It takes me a long time to do something 'right'.	●	●	●	●	●
The fewer mistakes I make, the more people will like me.	●	●	●	●	●
I never felt like I could meet my parents' standards.	●	●	●	●	●

4. Below are a number of adjectives. We would like you to use these words to describe yourself by indicating how true of you these various characteristics are. Please give your own opinion of yourself. If you are not sure, select the option that comes closest to what you think best describes you.

	Never or almost never true	Usually not true	Sometimes but infrequently true	Occasionally true	Often true	Usually true	Always or almost always true
Energetic (having energy/enthusiasm)	●	●	●	●	●	●	●
Idealistic (believing in principles)	●	●	●	●	●	●	●
Quiet (modest/reserved)	●	●	●	●	●	●	●
Outspoken (speaking one's mind)	●	●	●	●	●	●	●
Self-confident (self-assured)	●	●	●	●	●	●	●

	Never or almost never true	Usually not true	Sometimes but infrequently true	Occasionally true	Often true	Usually true	Always or almost always true
Cooperative (willing to assist)	●	●	●	●	●	●	●
Peaceable (tranquil/calm)	●	●	●	●	●	●	●
Aggressive (angry/hostile)	●	●	●	●	●	●	●
Quick (acting speedily)	●	●	●	●	●	●	●
Helpful (giving help)	●	●	●	●	●	●	●
Calm (not agitated/excited)	●	●	●	●	●	●	●
Forceful (strong/confident)	●	●	●	●	●	●	●
Enterprising (showing boldness/initiative)	●	●	●	●	●		●
Unrealistic (not practical/realistic)	●	●	●	●	●	●	●
Relaxed (not tense/rigid)	●	●	●	●	●	●	●
Headstrong (behaving in one's own way)		●	●	●	●	●	●
Tense (showing emotional strain)	●	●	●	●	●	●	●
Unstable (having changeable moods)	●	●	●	●	●	●	●
Enthusiastic (eager/interested)	●	●	●	●	●	●	●
Irritable (easily annoyed/angered)	●	●	●	●	●	●	●
Informal (relaxed/friendly)	●	●	●	●	●	●	●
Ambitious (desiring success)	●	●	●	●	●	●	●
Dominant (having control/influence)	●	●	●	●	●	●	●

	Never or almost never true	Usually not true	Sometimes but infrequently true	Occasionally true	Often true	Usually true	Always or almost always true
Assertive (confident/direct)	●	●	●	●	●	●	●
Sly (secretive)	●	●	●	●	●	●	●
Argumentative (likely to argue)	●	●	●	●	●	●	●
Excitable (easily excited)	●	●	●	●	●	●	●
Snobbish (regard for social status)	●	●	●	●	●	●	●
Mild (gentle)	●	●	●	●	●	●	●
Loud (demanding/forceful)	●	●	●	●	●	●	●
Individualistic (living in one's own way)	●	●	●	●	●	●	●
Stingy (very mean)	●	●	●	●	●	●	●
Easy-going (relaxed in manner/attitude)	●	●	●	●	●	●	●
Talkative (talking a great deal)	●	●	●	●	●	●	●
Outgoing (friendly/sociable)	●	●	●	●	●	●	●
Original (thinking of new ideas)	●	●	●	●	●	●	●
Cautious (careful/sensible)	●	●	●	●	●	●	●
Strong (self-confident)	●	●	●	●	●	●	●

5. Below are several statements concerning your opinions about exercise (i.e. running). Please choose the option that best describes how you feel.

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
Running is the most important thing in my life.	●	●	●	●	●

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
Conflicts have arisen between me and my family and/or my partner because of the amount of running I do.	●	●	●	●	●
I use running as a way of changing my mood (e.g. to get a buzz, or to escape, etc).	●	●	●	●	●
Over time I have increased the amount of running I do in a day.	●	●	●	●	●
If I have to miss a running session, I feel moody and irritable.	●	●	●	●	●
If I cut down on the amount of running I do, and then start again, I always end up running as often as I did before.	●	●	●	●	●

6. Please indicate your typical approach to training and competition by choosing the option that best describes your normal behaviour. Please be as honest as possible.

In general:

	Strongly disagree	Disagree	In between	Agree	Strongly agree
I would rest or do a short, easy run if I felt particularly tired or sluggish.	●	●	●	●	●
If I experienced pain while running, I would rest until I had fully recovered.	●	●	●	●	●
I would train hard or race even if I did not feel up to it physically.	●	●	●	●	●

	Strongly disagree	Disagree	In between	Agree	Strongly agree
I would try to "run through" symptoms of pain or injury.	●	●	●	●	●
I would abandon a training run if any muscle soreness persisted or worsened.	●	●	●	●	●
I would not train hard or compete if I was ill (e.g. had a cold, fever or sore throat)	●	●	●	●	●
I would ensure I stuck to my training programme regardless of how I felt.	●	●	●	●	●
If my performance worsened, I would train harder.	●	●	●	●	●
I would adjust my training schedule according to how my legs were feeling.	●	●	●	●	●
I would train hard or compete in spite of muscle soreness or stiffness.	●	●	●	●	●

7. Please describe a typical training week in your life during both heavier training periods (e.g. when leading up to a race or series of races) and lighter training periods (e.g. when recovering from a race or series of races). Please complete each row. If your training doesn't vary much, then please provide the same information in each row.

	Total weekly running distance	Total number of runs	Number of runs under 1 hr 30 min duration	Number of runs over 1 hr 30 min duration	Number of easy runs	Number of medium-intensity runs	Number of hard runs	Number of very hard runs
Heavier training periods								

	Total weekly running distance	Total number of runs	Number of runs under 1 hr 30 min duration	Number of runs over 1 hr 30 min duration	Number of easy runs	Number of medium-intensity runs	Number of hard runs	Number of very hard runs
Lighter training periods								

8. How many races do you run on average per year? Please complete each row.

	0	1	2	3	4	5	6	7	8	9	10 +
800 - 3 000m (track)	●	●	●	●	●	●	●	●	●	●	●
5 000 - 10 000m (track)	●	●	●	●	●	●	●	●	●	●	●
4 - 12kms	●	●	●	●	●	●	●	●	●	●	●
15 - 21,1kms	●	●	●	●	●	●	●	●	●	●	●
32 - 42,2kms	●	●	●	●	●	●	●	●	●	●	●
50 - 56kms	●	●	●	●	●	●	●	●	●	●	●
85 - 90kms	●	●	●	●	●	●	●	●	●	●	●

Other (please specify)

9. Please indicate whether you've had any running-related pain in your lower back, hips, pelvis, groin, buttocks, knees, legs, ankles or feet in the past three months. If "yes", then please rate the severity and duration of any pain you've had, and indicate how many days, if any, you stopped running due to such pain during this time ("time loss").

Please rate pain severity on a scale of 1 - 4 as follows:

1 = Felt pain after running only
2 = Felt pain during running that did not affect distance or speed
3 = Felt pain during running that affected distance and speed
4 = Felt pain that prevented all running

	Yes/No	Severity	Duration	Time loss
Lower back pain				
Hip/pelvis/groin pain				
Buttock pain				

	Yes/No	Severity	Duration	Time loss
Upper leg pain				
Knee pain				
Lower leg pain				
Ankle pain				
Foot pain				

10. Please indicate whether you've had any upper respiratory infections (e.g. colds, flu, coughs or sore throats) in the past three months. If "yes", then please indicate the number of times you've had infections, as well as their severity and duration, and the total number of days, if any, you stopped running due to such infections during this time ("time loss").

Please rate illness severity on a scale of 1 - 3 as follows:

1 = Infection was mild (i.e. did not restrict daily routine or activities)
2 = Infection was moderate (i.e. restricted daily routine or activities somewhat)
3 = Infection was severe (i.e. restricted daily routine or activities significantly)

For "duration", please indicate how long the infection lasted from the time symptoms first appeared to when they disappeared.

If you had more than one infectious episode, then please indicate their average severity and duration.

	Yes/No	Number	Severity	Duration	Time loss
Upper respiratory infections in the past three months					

11. The following items focus on how you have been feeling physically with respect to running-related pain in your lower body (i.e. lower back, hips, pelvis, groin, buttocks, upper legs, knees, lower legs, ankles, feet) and upper respiratory infections (e.g. colds, flu, coughs, sore throats), over the past 12 months. Please respond by choosing the appropriate option for each question.

Over the past 12 months:

	Not at all	Rarely	Once in a while	Some of the time	Fairly often	Often	All of the time
How often have you felt pain in any of the muscles, joints, etc. of your lower body during or after running?	●	●	●	●	●	●	●

	Not at all	Rarely	Once in a while	Some of the time	Fairly often	Often	All of the time
How often have you had to reduce your training due to running-related pain or discomfort?	●	●	●	●	●	●	●
How often have you been unable to run at all because of lower-body musculoskeletal pain?	●	●	●	●	●	●	●
How often has running-related pain affected your race participation or performance?	●	●	●	●	●	●	●
How often have you had minor colds (that made you feel uncomfortable but didn't keep you sick in bed or make you miss work/school)?	●	●	●	●	●	●	●
How often have you had respiratory infections more severe than minor colds (such as bronchitis, sinusitis, etc.) that "laid you low"?	●	●	●	●	●	●	●
How often have respiratory infections disrupted your training?	●	●	●	●	●	●	●
How often have respiratory infections affected your race participation or performance?	●	●	●	●	●	●	●

12. Please complete the following:

	Gender	Age	Population group	Running Club
Personal details				

13. Approximately how long have you been running?

- Less than 1 year
- 1 - 5 years
- 6 - 10 years
- 11 - 15 years
- 16 - 20 years
- 21 years +

14. Which statement best describes your current level of participation?

- I am a national level competitor (i.e. I have recently represented my country in international competition)
- I am a provincial level competitor (i.e. I have recently represented my province in national competition)
- I am an advanced competitor (i.e. I usually finish in the top 10 to 25 percent of the field in most races)
- I am a mid-level competitor (i.e. I usually finish in the middle of the field in most races)
- I am a basic competitor (i.e. I usually finish towards the back of the field in most races)

15. How many hours per week do you participate in endurance activities apart from running (e.g. spinning, cycling, rowing, canoeing, swimming)?

- 0 hours
- Less than 1 hour
- 1 - 2 hours
- 3 - 4 hours
- 5 - 6 hours
- 7 hours +

16. Do you suffer from any seasonal or year-round conditions affecting the respiratory tract (e.g. hay fever)?

- Yes
- No
- Not sure

17. Do you keep a daily record of your running activity?

- Always
- Usually
- Occasionally
- Never

18. Would you like to be entered into the shoe draw and/or receive feedback on the study results?

	Yes	No
Entry into shoe draw	●	●
Results feedback	●	●

19. If you answered 'yes' to either of the above, then please provide your e-mail address below:

Thank you for your participation!