INDIVIDUAL DIFFERENCES IN STRESS REACTIVITY: IMPLICATIONS FOR ADOLESCENT ATHLETES' PERFORMANCE AND WELL-BEING

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Copyright Statement

Abstract

Individual differences play a significant role in the outcomes experienced by adolescent athletes, in what is a highly stressful period of their development. Stress reactivity is a stable individual difference underlying the broad variability in responses to stress, which has received very little attention within sporting contexts. Therefore, this PhD aims to establish stress reactivity as a critical individual difference influencing the outcomes experienced by adolescent athletes.

A systematic review of the literature was firstly conducted in order to assess how individual differences in stress reactivity are measured in adolescents, and the long-term outcomes associated with stress reactivity. Hyper-reactivity was associated with internalising symptoms, negative emotionality, depression, anxiety, and social withdrawal during adolescence and in later life. However, what was lacking in the literature were ecologically valid measures of stress reactivity that capture responses to multiple real-world stressors. This was of importance for the aim of assessing stress reactivity specifically within sporting contexts.

Therefore, study one adapted the Perceived Stress Reactivity Scale (Schlotz, Yim, Zoccola, Jansen, & Schulz, 2011) to measure individual differences in perceived stress reactivity in adolescent athletes, testing model fit, internal consistency, criterion validity, and test re-test reliability. 243 adolescent athletes completed the adapted scale, plus measures of the Big 5 personality traits, perceived stress, and life satisfaction. The Perceived Stress Reactivity Scale for Adolescent Athletes (PSRS-AA) produced adequate model fit from a confirmatory factor analysis, and good internal consistency and test re-test reliability for the scale's aggregate score of total reactivity. Perceived stress reactivity was associated with higher neuroticism and introversion, less openness, greater perceived stress, and lower life satisfaction.

In study 2, a path analysis was conducted to investigate the direct and indirect effects of perceived stress reactivity on the stress and coping process. 229 adolescent athletes completed the PSRS-AA and a measure of stress appraisal prior to competition, followed by measures of emotion, coping, and performance satisfaction after competing. Perceived stress reactivity had direct effects on the appraisal of stress intensity, perceived control, and threat prior to competition, and on negative emotions reported post-competition. Indirect effects were also observed on perceived challenge, and disengagement and distraction-orientated coping. However, no effects were observed on subsequent performance satisfaction.

Study 3 (a two-part study) tested the validity of the scale further, and its relationships with measures of emotion regulation. Firstly, 216 adolescent athletes completed the PSRS-AA and measures of trait reinvestment and trait emotion regulation. Confirmatory factor analysis again provided adequate model fit, while perceived stress reactivity was associated with trait movement self-consciousness, and partially associated with trait emotional suppression and cognitive re-appraisal. Thirty student athletes and thirty one student non-athletes then completed either the PSRS-AA or the original PSRS and took part in a socially evaluated cold pressor test while their heart rate variability (HRV; a psychophysiological measure of emotion regulation) was recorded. Controlling for gender and athleticism, the PSRS-AA showed no associations with tonic or phasic levels of HRV. However, the perceived stress reactivity did predict levels of perceived stress and pain experienced during the cold pressor test.

This thesis makes a number of novel contributions to both theory, methodology, and applied practice. The PSRS-AA provides a valid and reliable measure of adolescent athletes’ individual differences in perceived stress reactivity and is associated with a number of adverse psychological processes and outcomes. The PSRS-AA could be used as a screening tool to identify adolescent athletes with high levels of stress reactivity, and thus those who may be at the greatest risk of the adverse outcomes identified in this thesis. However, further research is required to confirm the scale's association with physiological processes and measures of stress reactivity. Further research is also required to establish the relationship between stress reactivity and emotion regulation in adolescent athletes. Future research should also look to examine the factors which contribute to the development of stress reactivity before and during adolescence in athletes, given the large number of stressors they experience, in order to understand how such individual differences may lead to talented athletes failing to fulfil their potential.

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List of Abbreviations

SR – Stress Reactivity

HPA – Hypothalamic Pituitary-Adrenal Axis

ANS – Autonomic Nervous System

PFC – Pre-Frontal Cortex

ERQ – Emotion Regulation Questionnaire

HF-HRV – High Frequency Heart Rate Variability

PSR – Perceived Stress Reactivity

PSRS – Perceived Stress Reactivity Scale

PSRS-AA – Perceived Stress Reactivity Scale for Adolescent Athletes

PSS – Perceived Stress Scale

TIPI – Ten Item Personality Inventory

BMSLSS – Brief Measure of Student Life Satisfaction

CFA – Confirmatory Factor Analysis

CMIN/DF – Chi-squared/Degrees of Freedom

CFI – Comparative Fit Index

RMSEA – Root Mean Square Error of Approximation

ICC – Intraclass Correlation Coefficients

VAS – Visual Analogue Scale

SEQ – Sport Emotion Questionnaire

CICS – Coping Inventory for Competitive Sport

MSC – Movement Self Consciousness

CMP – Conscious Motor Processing

MSRS- Movement Specific Re-Investment Scale

SECPT – Socially Evaluated Cold Pressor Test

RSE – Reactivity to Social Evaluation

CBT – Cognitive Behavioural Therapy

REBT – Rational Emotive Behaviour Therapy

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Lastly, along with my parents, I would like to dedicate this thesis to my late brother Gavin, who we still miss every day.

Preface

This thesis includes chapters and content that are in various stages of the publishing process. These include published manuscripts, manuscripts under review, and conference presentations. The details of all outputs related to this thesis are as follows:

Journal articles

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Britton, D., Kavanagh, E., & Polman, R. (2018). A path analysis of adolescent athletes' perceived stress reactivity, appraisals, emotions, coping, and performance satisfaction. Manuscript submitted for publication.

Britton, D., Kavanagh, E., & Polman, R. (2018). Perceived stress reactivity in adolescent and student athletes: Associations with re-investment, emotion regulation, heart rate variability, and stress appraisals. Manuscript submitted for publication.

Conference presentations

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Contents

Chapter 1. General Introduction

The aim of this chapter is to introduce the main conceptual and theoretical areas within the thesis. It will firstly introduce the role of stress in the development of adolescents in general. Stress will then be considered in relation to adolescents participating in competitive sport. Contextualised within Lazarus and Folkman's (1987) transactional model, the role of individual differences within the stress and coping processes of athletes will be introduced. Stress reactivity (SR) will be introduced as an individual difference yet to receive significant attention within sporting contexts. It is finally proposed that individual differences in SR may have significant implications for adolescent athletes' well-being and performance. Therefore, a number of aims, objectives, and predictions are made with regards to the development of a measure of adolescent athletes individual differences in SR, plus the performance and well-being-related outcomes SR may be associated with.

1.1. Adolescent development and stress

Adolescence is understood to be a complex period whereby an individual transitions from a dependent child into an independent adult (Blakemore & Choudhury, 2006). It is an inherently stressful period of life; characterised by dramatic physical, psychological, and social changes (Compas, Connor-Smith, Saltzman, Thomsen, & Wadsworth, 2001). Adolescents must contend with their burgeoning physical and emotional development, changing social roles and pressures, their growing independence from their parents, as well as academic commitments (Compas et al., 2001; van Rens, Borkoles, Farrow, Curran, & Polman, 2016). This is all while their reactivity to stress, plus their ability to cope with stressors, develops during adolescence (Blakemore & Choudhury, 2006; Nicholls, Polman, Morley, & Taylor, 2009; Romeo, 2010).

Research has proposed a 'developmental mismatch' to explain how adolescents' ability to cope with stress develops at a neural level, in that the development of pre-frontal regions responsible for cognitive control, emotion regulation, and social cognition, lags behind the development of limbic structures (such as the amygdala) which produce fear responses and emotional saliency (Ahmed, Bittencourt-Hewitt, & Sebastian, 2015; Dumontheil, 2016). These neurological changes help to explain why adolescents can initially be less effective at coping with stress and regulating their emotions, and can be sensitive to social influences from peers, including evaluation and exclusion (Dumontheil, 2016). It also explains why, over time, adolescents have the capacity to develop an enhanced repertoire of coping skills and regulatory strategies, as the pre-frontal regions catch up with the development of the limbic structures (Compas et al., 2001). These structural and functional developments continue well into an individual's mid-twenties (Blakemore & Choudhury, 2006). Therefore, although adolescence has been historically defined as a narrower age range (e.g. 12-22 years; Sullivan, 1953), recent research has aimed to expand traditional age brackets of adolescence to 10 to 25 years of age in order to reflect these developments in understanding, as well as socio-cultural changes within western society (Sawyer, Azzopardi, Wickremarathne, & Patton, 2018).

1.2. Stress and coping among adolescent athletes

There are many performance-related stressors which young athletes must cope with, including physical and mental errors, criticism, risk of injury, and pressure to perform (Nicholls, Holt, Polman, & James, 2005; Reeves, Nicholls, & McKenna, 2009). There can also be multiple organisational stressors which athletes must contend with, such as team selection, conflicts with team-mates and coaches, travel, and, within the higher echelons of competition, gaining or maintaining contracts and funding (Arnold, Fletcher, & Daniels, 2017). These sport specific stressors can coincide with numerous stressors associated with adolescence, as well as the neuro-developmental changes that occur during this period (Blakemore & Choudhury, 2006; Compas et al., 2001; van Rens et al., 2016).

Stress, if not coped with adaptively, can have a significant impact upon the outcomes experienced by adolescents, with implications for their performance, well-being, and development. In terms of performance, increased stress is associated with unpleasant emotions (such as anxiety, guilt, and shame) and performance dissatisfaction in athletes (Lazarus, 2000; Nicholls, Polman, & Levy, 2012). Inability to cope with stress has been cited as one of the main reasons why some, if not many, talented youth athletes fail to successfully transition to elite adult level (Holt & Dunn, 2004). Furthermore, stress has been identified as a significant cause of both youth athlete burn-out and dropout from sport (Crane & Temple, 2015; Goodger, Gorely, Lavallee, & Harwood, 2007; Smith, 1986).

Despite the numerous stressors associated with both sport and adolescence, Lazarus and Folkman (1987) proposed that stress emerges due to a transaction between an individual and their environment in their Transactional Model of Stress and Coping (see Figure 1). It is this interaction which influences how individuals, including athletes, appraise and cope with stress, and thus the outcomes they experience (Lazarus & Folkman, 1987). Firstly, an appraisal is made of the potentially stressful situation. This initially comprises of the primary appraisal of perceived stress intensity and the demands of the situation, alongside the secondary appraisal of perceived control over the situation and the resources available to cope (Lazarus & Folkman, 1987). A relational meaning is then formed from these appraisals. The relational meaning is that of either a challenge, a threat, or benign to the individual's goals or well-being. For example, an appraisal of high demands and but also high control often produces a meaning of perceived challenge to the individual, while high demands but low control produces a perceived threat (Lazarus & Folkman, 1987; Nicholls et al., 2012). Low demands likely leads to the situation being perceived as benign, and thus no conscious efforts to cope are required. The appraisals and relational meanings then drive the conscious selection of coping strategies, with challenge appraisals being associated with adaptive coping, and threat appraisals with maladaptive coping (Kerdijk, van der Kamp, & Polman, 2016; Lazarus & Folkman, 1987; Nicholls et al., 2012).

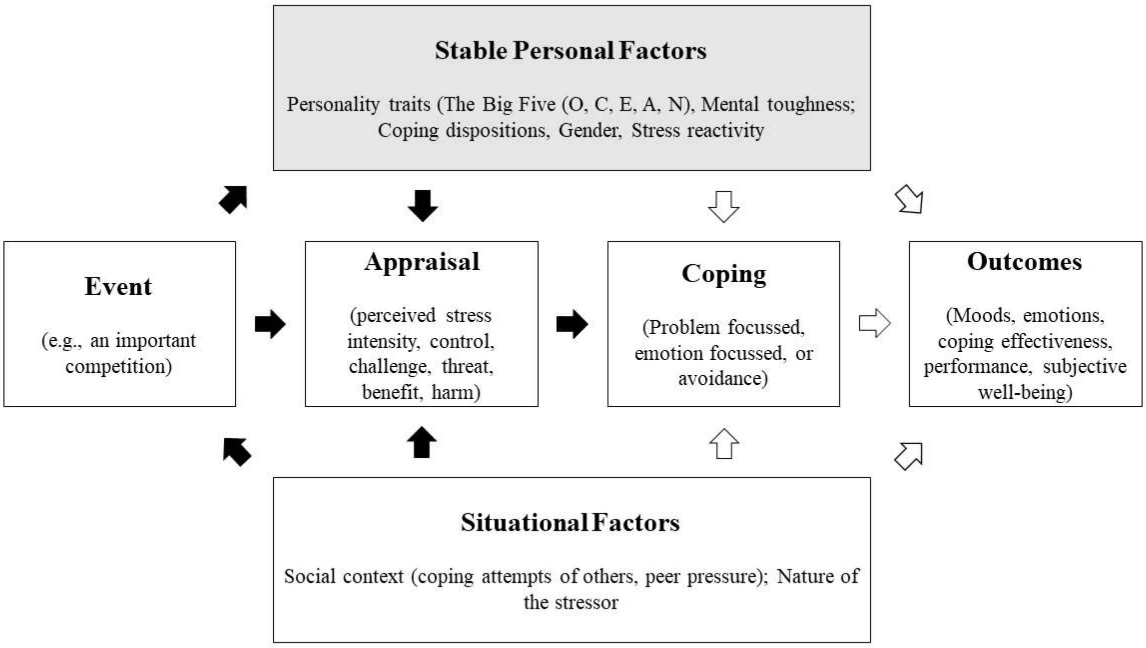

Figure 1: Conceptual framework illustrating how stable and situational factors directly and indirectly influence the stress and coping process (Kerdijk et al., 2016). Black arrows represent direct effects, while white arrows indicate indirect effects. (Permission granted from corresponding author R. Polman).

Athletes have been found use a wide variety of coping strategies (Nicholls & Polman, 2007). Coping strategies have been grouped into numerous higher-order dimensions in research with athletes and the wider population. The distinction between problem-focussed (attempts to practically address and nullify a stressor), emotion-focussed (attempts to address the emotional response caused by a stressor), and avoidance-focussed (attempts to physically or mentally avoid a stressor) coping strategies has been widely applied in the general population (Lazarus & Folkman, 1987). However, in athletes, the distinction between task-orientated (attempts to address the sporting task at hand), distraction-orientated (attempts to distract oneself from the task at hand), and disengagement-orientated (attempts to physically or emotionally disengage from the activity) has also been applied, although not exclusively (Gaudreau & Blondin, 2002). In athletes, challenge appraisals have been associated with a greater use of task-orientated coping strategies, while threat appraisals are associated with both distraction and disengagement-orientated coping (Nicholls et al., 2012). Furthermore, task-orientated coping is associated with more positive emotions and greater performance satisfaction, while distraction and disengagement are associated with negative emotions and lesser performance satisfaction (Nicholls et al., 2012).

1.3. Individual differences in athlete stress and coping

Compas et al. (2001) extended the work of Lazarus and Folkman by proposing that coping is constrained by the maturational level of an individual, and this has been found to be the case in adolescent athletes. Pubertal, emotional, and cognitive-social maturity have all been shown to influence how young athletes cope with the stress they experience (Nicholls, Levy, & Perry, 2015; Nicholls, Perry, Jones, Morley, & Carson, 2013; Nicholls et al., 2009). Specifically, increased maturity has been associated with greater use of task-orientated coping, and greater coping effectiveness among adolescent athletes. This supports many of the theories regarding adolescent development discussed in 1.1 (Ahmed et al., 2015; Blakemore & Choudhury, 2006).

Numerous other individual differences have been found to influence how athletes appraise and cope with the stressors they experience. For example, gender has been shown to be a significant factor with males more likely to use problem-focussed coping strategies, and females, emotion-focussed coping (Kaiseler, Polman, & Nicholls, 2012b; Nicholls, Polman, Levy, Taylor, & Cobley, 2007). Moreover, personality traits also have significant influences how athletes appraise and cope with stressful events. Within the Big Five personality traits, neuroticism is associated with the appraisal of greater stressor intensity, lower perceived control, the use of more emotion and avoidance focussed coping strategies, and lesser coping effectiveness (Kaiseler, Polman, & Nicholls, 2012a). Meanwhile, agreeableness has been associated with lesser stress intensity, and conscientiousness with greater perceived control (Kaiseler et al., 2012a). The trait of mental toughness has also been linked to the use of more problem-focussed coping strategies and less emotion-focussed and avoidance strategies (Kaiseler, Polman, & Nicholls, 2009). However, given the increased sensitivity to stress experienced by adolescents during this period, little research has examined the effects of individual differences in stress reactivity on the outcomes experienced by youth athletes.

1.4. Stress reactivity

SR has been operationalised as an individual difference underlying the broad variability in responses to stressors (Boyce & Ellis, 2005; Ellis, Essex, & Boyce, 2005; Schlotz, 2013; Schlotz, Hammerfald, Ehlert, & Gaab, 2011; Schlotz, Yim, et al., 2011). Heightened SR reflects an increased ‘biological sensitivity to context’, where ‘hyper-reactive phenotypes' will experience greater and more prolonged stress reactions in response to their environment (Boyce & Ellis, 2005). Individual differences in reactivity are associated with a greater risk of stress-related illness and other adverse outcome via the process of allostasis and the consequences of allostatic load (McEwen, 1998; McEwen & Seeman, 1999).

Allostasis is a process whereby physiological (the nervous system, the endocrine system, and the immune system) and neurobiogical systems (such as the thalamus, amygdala, hippocampus, and pre-frontal cortex) detect and respond to internal and external changes (i.e. stressors), and attempt to maintain stability through change and adaptation (Danese & McEwen, 2012). This is in order to achieve homeostasis (i.e. stability), with allostasis promoting short-term adaptation to stressors (i.e stability through change). However, repeated and chronic exposure to psycho-social stressors, and thus prolonged activation of allostatic systems, have detrimental physiological consequences in the long-term, and is referred to as allostatic load (Danese & McEwen, 2012). Many of the hormonal secretions produced by physiological allostatic systems designed to promote allostasis (such as cortisol) are beneficial in the short-term, but have detrimental consequences if produced for a sustained period of time, and develop 'wear and tear' on the body (McEwen, 2005). At a neurological level, allostatic load (or the more severe allostatic overload) is associated with impairment of attention, memory, and emotion regulation (Danese & McEwen 2012). There are four scenarios in which allostatic load can occur: 1) When an individual is exposed to repeated novel stressors, requiring persistent adaptation and activation of allostatic systems. 2) When there is a lack of adaptation to stressors over time. 3) When there are prolonged physiological responses to stressors. 4) When there are inadequate physiological responses by one allostatic system, leading to increased compensatory responses from other systems (McEwen & Seeman, 1999). Thus, increased SR at a trait-level is likely to impact detrimentally upon individuals via increased allostatic load.

SR is a stable trait developed via exposure to chronic and acute stress (Boyce & Ellis, 2005; Ellis et al., 2005). Increased SR has been linked to exposure to chronic stress in both childhood and adolescence (Hughes et al., 2017; Romeo, 2010). Exposure to chronic stress leads to changes in the development of allostatic systems, and thus impaired cognitive, social, and emotional functioning, plus increased allostatic load (Hughes et al., 2017).

SR can be measured using many methods. Typically, controlled laboratory assessments such as the Trier Social Stress Test (Kirschbaum, Pirke, & Hellhammer, 1993; Schlotz, Yim, et al., 2011) or the Socially Evaluated Cold Pressor Test (Schwabe, Haddad, & Schachinger, 2008) are utilised. Different stress response systems can then be assessed during these procedures. For example, neuroendocrine responses can be measured via the hypothalamic-pituitary-adrenal (HPA) axis and the production of hormones such as cortisol. Physiological responses can be measured via the autonomic nervous system (ANS), comprising of the sympathetic nervous system, which increases arousal, and the parasympathetic nervous system, which decreases arousal. For example, heart rate variability has been utilised as an index for parasympathetic activation in athletes and the general population, based on the Neural Visceral Integration Model (Laborde, Mosley, & Thayer, 2017; Mosley, Laborde, & Kavanagh, 2017; Thayer, Åhs, Fredrikson, Sollers, & Wager, 2012). Using controlled procedures coupled with novel stressors creates an assessment with internal validity and test re-test reliability.

In athletic contexts, however, there can be difficulties in measuring SR (Polman, Clough, & Levy, 2010). In more ecologically valid sporting situations, stress reactions may be influenced by numerous situational factors (such as playing conditions and opponents), as well as an individual's specific margin of reactivity. It is also difficult to establish whether stress reactions are as a result of either the psychological or physical demands of sporting activity being performed (Polman et al., 2010). Furthermore, it is problematic to generalise stress reactions in response to one stimulus as reflective of reactivity to all stimuli (Schlotz, 2013). This is known as 'stimulus response specificity', where previous exposures to different types of stressor are likely to lead to variability in reactivity across different stress domains and response systems (Schlotz, 2013). The HPA is often considered to index responses to social stress, while the ANS is reflective of increased effort or arousal (Schlotz, Yim, et al., 2011). But to measure multiple reactions to different procedures with multiple stimuli has the potential to be costly, time-consuming, and difficult to conduct (Schlotz, Yim, et al., 2011).

SR has not been measured or examined in adolescent athlete populations as a stable individual difference. The study of SR could further add to the understanding of the development of adolescent athletes, particularly how stress-related processes influence their performance and well-being.

1.4.1. SR, personality, and individual differences

It has been proposed that personality traits are the result of differential reactivity to environmental stimulation, with high levels of neuroticism and introversion being the result of hyper-reactivity (Suls & Martin, 2005). Furthermore, gender differences in coping have been attributed to biological variations in reactivity between males and females (Tamres, Janicki, & Helgeson, 2002). Therefore, one would expect a measure of adolescent athletes' SR to be associated with certain personality traits, particularly neuroticism and introversion, and for SR to be greater in adolescent female athletes compared to their male counterparts. SR is also likely to be associated with further traits related to skill failure under pressure, such as trait re-investment (Masters & Maxwell, 2008). This is because stress and negative affectivity are regarded as a contingency for the process of re-investment, where self-focussed attention under pressure disrupts skill execution, resulting in poor performance. Therefore, adolescent athletes with high levels of SR are potentially more likely to perform poorly under pressure.

1.4.2. SR and wellbeing

With individual differences in SR influencing the strength and length of stress reactions experienced (Schlotz, 2013), one would expect adolescent athletes high in SR to experience more stress over time. Furthermore, with stress being a significant determinant of youth athlete burnout and dropout (Crane & Temple, 2015; Goodger et al., 2007) one would expect higher levels of SR in adolescent athletes to be associated with poorer wellbeing, indexed by life satisfaction. Across different domains of life satisfaction, adolescent athlete SR is most likely to be associated with dissatisfaction with one's sporting experience, but also cross over into other life domains as well. This is due to SR ultimatley being a stable trait across contexts.

1.4.3. SR, stress appraisal, emotion, and coping

Given the direct and indirect effects of numerous individual differences on the transactional process of stress (such as neuroticism and introversion; Kaiseler et al. 2009; Kaiseler et al., 2012a; see Figure 1), it is proposed that adolescent athletes' SR will have similar effects. Specifically, it is proposed that SR will influence this process directly via appraisal of greater stressor intensity, greater threat, less perceived control, and more negative emotions. Furthermore, via these direct effects, SR will have an indirect effect on the coping strategies used by adolescent athletes, and thus their resulting performance.

1.4.4. SR and emotion regulation

The processes of both stress-coping and emotion regulation share many similarities (Wang & Saudino, 2011). At a neural level, both are associated with activation of the pre-frontal cortex (PFC), and the modulation of responses from the amygdala. Both processes are also associated with activation of the HPA. Emotion regulation predicts cortisol elevations in response to stress, and both processes involve the modulation of both affective and cognitive responses (in the form of appraisals) to events or states (Wang & Saudino, 2011). Of importance to this study, the shared neural networks and structures also associated with emotion regulation also develop during adolescence (Ahmed et al., 2015; Blakemore & Choudhury, 2006). Therefore, one would propose that measures of adolescent athletes' SR are likely to be highly related to both state and trait measures of emotion regulation.

Trait measures of emotion regulation include questionnaire measures such as the Emotion Regulation Questionnaire (ERQ; Gross & John, 2003). High levels of SR are likely to be associated with regulatory strategies considered to be less adaptive (such as emotional suppression). State measures include physiological indices such as high frequency heart rate variability (HF-HRV). The Neurovisceral Integration model proposes a bi-directional connection between the heart and the brain via the vagus nerve. Increases in HF-HRV index activation of the parasympathetic nervous system and the PFC (Thayer et al., 2012). This in turn increases the PFC's inhibitory control over the amygdala, thus regulating emotions. High levels of SR are likely to be associated with lower levels of HF-HRV, and thus less effective emotion regulation (Thayer et al., 2012). However, differences in gender and athleticism may also influence HF-HRV and therefore need to be controlled for within an adolescent sample (Stanley, Peake, & Buchheit, 2013; Woo & Kim, 2015).

This programme of research therefore identified a number of aims and objectives in order to examine the role of SR in the development of adolescents, particularly in relation to personality and individual differences, well-being, stress appraisal and coping, emotion regulation, and performance.

1.3. Aims and objectives

1.3.1 Aims

A1. Develop and validate a measure for assessing adolescent athletes' individual differences in SR in relation to sporting contexts.

A2. Investigate the performance and well-being related outcomes associated with individual differences in adolescent athletes' SR.

1.3.2 Objectives

O1. Examine the association between adolescent athletes' SR and related measures of personality, perceived stress, and subjective well-being.

O2. Examine the role of SR in the stress appraisal, emotion, and coping process in a sample of adolescent athletes.

O3. Examine the association between SR and a physiological measure of stress and emotion regulation (HF-HRV) in a sample of student athletes and non-athletes.

1.4 Structure of the research thesis

The following thesis will present one systematic review and three empirical studies (the last of which is split into two). The systematic review presented in chapter 2 aims to establish the outcomes associated with SR in the wider adolescent population, plus the methods used to assess SR in these groups. A qualitative synthesis of the findings is presented, given that a large range of different outcomes and measures were identified. This was designed to inform the selection of a measure of adolescent SR to adapt for athletic populations. Chapter 3 presents an empirical study designed to adapt and validate a measure of adolescent athletes' SR. Building upon this, chapter 4 examines the direct and indirect effects of SR (using the measure validated in chapter 3) on adolescent athletes' appraisal, emotion, coping, and subjective performance using a path analysis. Finally, chapter 5 aims to further validate the measure of adolescent athlete SR, examining correlations with specific traits associated with performance and emotion regulation in adolescents, plus the predictive validity of the measure in relation to a physiological index of emotion regulation (HF-HRV) observed in students athletes and non-athletes.

Chapters 2, 3, 4, and 5 are introduced and discussed individually as separate pieces of research. Therefore, there may be repetition of material across these chapters. The final discussion chapter summarises the findings of the studies, before discussing the theoretical implications in relation to the thesis' two main aims. Implications for applied practice are also discussed, along with the limitations of the studies and directions for future research. An outline of the thesis structure can be observed in Figure 2.

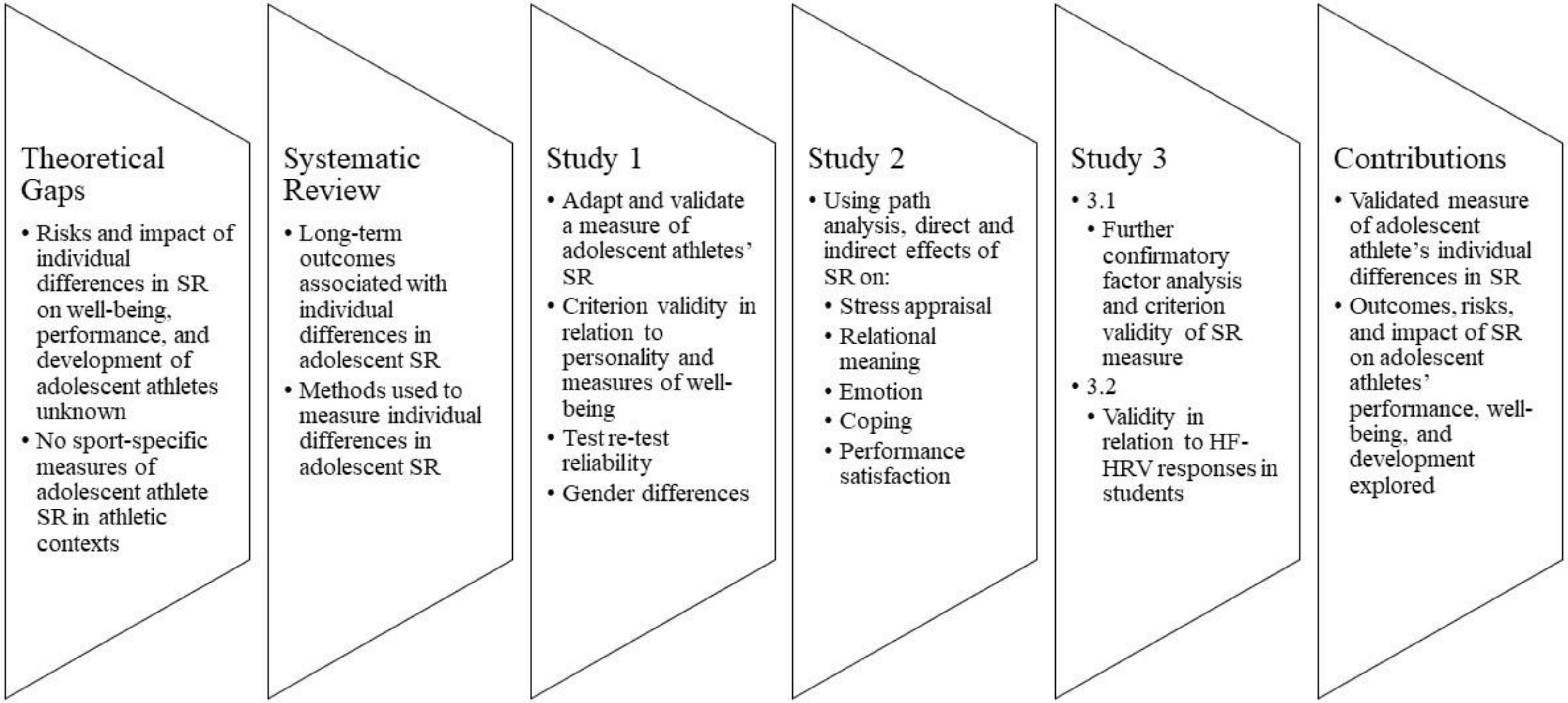

Figure 2: Structure of the thesis

Chapter 2. Adolescent stress reactivity: A systematic review with implications for research and practice in sport

Chapter 1 provided an initial rationale for the investigation of adolescent athlete's individual differences in SR. However, it was noted that individual differences in SR are difficult to assess within the context of sport (Polman et al., 2010), and hence why such individual differences have been under-researched within athletic populations. Therefore, this systematic review aimed to review the wider research literature in order examine the long-term outcomes associated with adolescent's individual differences in SR, and the methods employed to assess these individual differences (A1, A2). This was designed to help inform the selection of a measure of SR to be employed by this thesis for future studies, and to develop a greater understanding of the outcomes associated with individual differences in adolescent SR, and how these might impact upon athletes.

2.1. Introduction

It has been recognised that adolescence is an extremely stressful period for young athletes (Compas et al., 2001; van Rens et al., 2016). This is due to a number factors (including selection for competitions, social evaluation, family influences, and academic stress) in what is a critical stage of their development (Compas et al., 2001; Nicholls et al., 2015; Reeves et al., 2009; van Rens et al., 2016). An inability to cope adaptively with stressors can lead athletes to experience unpleasant emotions and performance detriments (Lazarus, 2000; Nicholls et al., 2012). Moreover, stress has been cited as a significant factor influencing both burn-out and drop-out from youth sport (Crane & Temple, 2015; Goodger et al., 2007).

Lazarus and Folkman's transactional model of stress and coping proposes that stress emerges from a transaction between a person and their environment, subsequently influencing their subjective appraisal of potentially stressful events and their attempts to cope (see Figure 1). Individual differences have therefore been shown to have many direct and indirect effects on how young athletes respond to stress, and whether they experience positive and negative outcomes despite the vast number of stressors they experience (see Figure 1; Kaiseler et al., 2009; Kaiseler et al., 2012a; Kaiseler et al., 2012b; Kerdijk et al., 2016). Therefore, individual differences in responses to stress can help identify athletes who are more or less likely to be successful in managing the multiple demands of competing in their sport, and their life more broadly.

SR has been operationalised as an individual difference underlying the broad variability in responses to stressors (Boyce & Ellis, 2005; Ellis et al., 2005; Schlotz, 2013; Schlotz, Hammerfald, et al., 2011; Schlotz, Yim, et al., 2011). Heightened SR reflects an increased biological sensitivity to context, where hyper-reactive phenotypes will experience greater and more prolonged stress reactions in response to their environment, thus putting them at greater risk of stress-related illness and other adverse outcomes (Boyce & Ellis, 2005). SR is a stable trait, and greater levels in adolescence and later life have been associated with increased exposure to stress and adversity during early childhood (Boyce & Ellis, 2005; Hughes et al., 2017). However, adolescence has also been cited as a significant period wherein SR develops, due to maturational processes and an increase in stressors (Ahmed et al., 2015; Romeo, 2010).

SR can be indexed using laboratory assessments of responses to stress induction procedures, such as the Trier Social Stress Test (Kirschbaum et al., 1993). Different stress response systems can then be assessed during these procedures. For example, neuroendocrine responses can be assessed via the hypothalamic-pituitary-adrenal axis

(HPA) and the production of hormones such as cortisol. Physiological responses can be assessed via the autonomic nervous system (ANS), comprising of the sympathetic nervous system, which increases arousal, and the parasympathetic nervous system, which decreases arousal. However, in athletic contexts, there are difficulties in measuring stress reactivity (Polman et al., 2010). In more ecologically valid situations, stress responses may also be influenced by numerous situational factors, as well as individual differences in SR. It is also difficult to establish whether stress responses are a result of either the psychological or physical demands of sport (Polman et al., 2010). Furthermore, it is problematic to infer that responses to one stressor are reflective of reactivity to all stressors (Schlotz, 2013). To measure multiple responses to multiple procedures has the potential to be costly, time-consuming, and difficult to conduct (Schlotz, Yim, et al., 2011).

SR has not been measured or examined in adolescent athlete populations as a stable individual difference. The study of SR could further add to the understanding of how individual differences influence the outcomes experienced by adolescent athletes. In the broader literature, 'long-term outcomes' associated with stress have been defined as consisting of physical health, subjective well-being, and social functioning (Lazarus & Folkman, 1987). Therefore, a review of SR in the wider literature is required so that future research in sporting contexts is appropriately informed in how to measure SR in adolescents (i.e. what are the most commonly used methods and are they valid for assessing SR in that specific population) and what long term outcomes are to be expected. This greater understanding of SR individual differences in adolescent athletes and its associated outcomes, could pave the way for practitioners to better help individuals cope with the stress that accompanies elite youth sport, enhancing well-being, and reducing levels of burnout and dropout.

This systematic review had two main purposes; (a) To identify the methodologies used to measure individual differences in SR in healthy non-athlete adolescents and (b) To identify the long-term outcomes associated with individual differences in SR in non-athlete adolescents. The implications of these findings are discussed in relation to potential research and practice within sporting contexts.

2.2. Methods

2.2.1. Searches

Previous systematic literature reviews within similar fields of study to this research (stress and coping in sport) were drawn upon, such as Nicholls and Polman (Nicholls & Polman, 2007), in order to guide the method for this systematic review. Studies were obtained through electronic literature searches on MEDLINE Complete, PsycINFO, PsycARTICLES and SPORTDiscus (1990 to 2015), which were all searched in December 2015. The literature search was limited to 1990 onwards in order to ensure that the reviewed research was current and up to date, with SR being a relatively recent area of research.

2.2.2. Inclusion and exclusion criteria

Articles were required to be published in academic peer-reviewed journals, and in the English language. Using the search terms ‘stress reactivity’, ‘personality’ or ‘traits’ or ‘individual differences’, and “adolescen*’, studies were considered for inclusion if they measured SR as a stable individual difference or trait in healthy adolescents and provided data on any form of subsequent long-term outcome, either measured longitudinally or cross-sectionally. Long-term outcomes referred to three general categories: Physical health, subjective well-being, and social functioning, as defined by Lazarus and Folkman as the long term outcomes of the stress and coping process

(Lazarus & Folkman, 1987). Some lines of research used the term ‘stress reactivity’ as a synonym for a single observed stress response or manipulated outcome, rather than as a stable individual difference. These papers, therefore, did not meet the inclusion criteria for this review.

Sifting was carried out in three stages. Papers were first reviewed by title, then by abstract, and then by full text. At each step, papers were excluded if they did not satisfy the inclusion criteria. At the first stage, 379 Papers were retrieved from the initial electronic database searches. However, 327 papers were excluded on title alone for not meeting the inclusion criteria. These excluded papers did not study adolescents, SR individual differences, or long-term outcomes (physical health, subjective well-being, or social functioning). 46 Abstracts were then reviewed, with 25 papers then excluded for not meeting the search criteria at this stage. 21 Papers were then reviewed in full, with nine excluded, leaving a final 12 papers in the systematic review (Figure 3). There were no disagreements within the research team on this process.

2.2.3. Data synthesis and presentation

A qualitative analysis synthesises the findings of this review, as the selected studies use multiple different measures of SR and report multiple long-term outcomes (Table 1). The results section reports the methods used to measure individual differences in SR in three categories: neuroendocrine, physiological, and self-report. The results section also presents the long-term outcomes reported by the chosen studies, in relation to the measure of SR they are associated with.

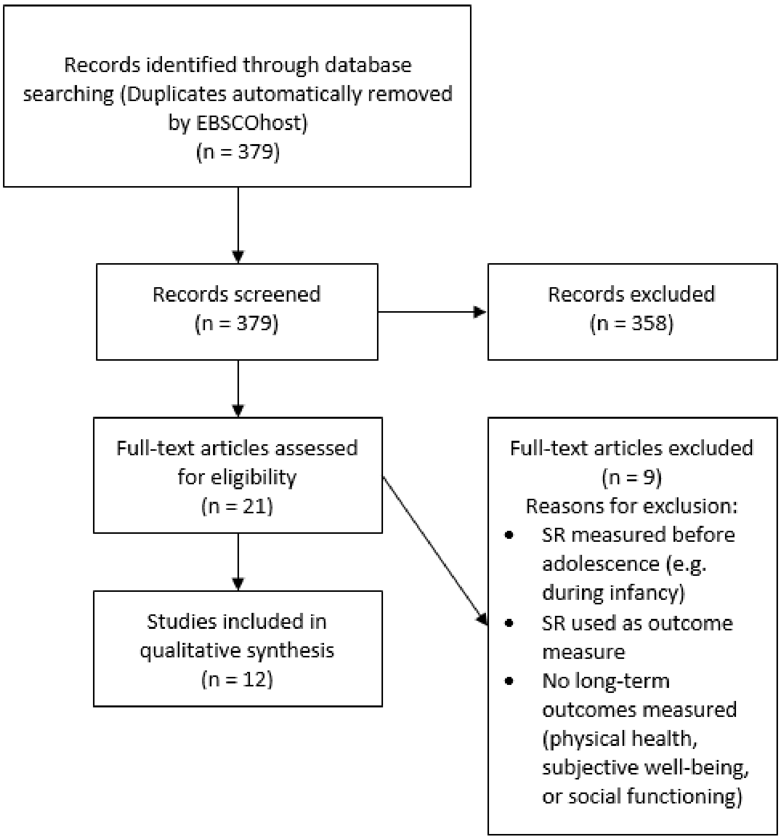

Figure 3: Systematic screening of papers using the PRISMA method.

Table 1: Summary of selected studies

Study	Participant information	Methodology (Longitudinal/Cross-sectional)	Key findings
Allwood et al.(2011)	56 (52% Female), mean age = 12	SAA and cortisol, BP and HR during speech, mirror tracing, mental arithmetic, and peer rejection (Cross-sectional)	Baseline SAA associated with greater HR. Baseline SAA positively associated with trait anxiety (r=.35). Increased cortisol associated with internalising symptoms.
Charbonneau et al. (2009)	315 (51% Female), mean age = 15	APES (Cross-sectional)	High reactivity associated with stress (r=.42) and depressive symptoms (r=.46). Higher emotional reactivity in girls (d=.24).
Colich et al. (2015)	89 Females, mean age = 12.5	Cortisol during serial subtraction task and social competence interview (Longitudinal)	Onset of MDD predicted by cortisol hypo-reactivity in early pubertal maturing girls, and hyperreactivity in later maturing girls (R^2=.556).
Dobkin et al. (1998)	89 Males, mean age = 16	HR and BP during social competence interview (Cross-sectional)	Lower reactors more disruptive and engaged in more risky health behaviours.
Granger et al. (1994)	102 (61% Male), mean age = 12.1	Cortisol sampled during parent-child conflict task (Cross-sectional)	High reactors engaged in more social withdrawal, experienced more social anxiety, and more likely to make external attributions for personal successes.
Lopez-Duran et al. (2015)	115 (55% Male), mean age = 12.8	Cortisol sampled before and after a socially evaluated cold presser task (Cross-sectional)	Depressive symptoms associated with prolonged response and impaired recovery from stressors. Greater cortisol peak levels were observed in boys.
Marceau et al. (2012)	108 (52% Male), mean age = 12.3	Cortisol, testosterone and dehydroepiandrosterone measured during venepuncture paradigm procedure (Longitudinal)	In boys only, reactivity predicted negative emotionality and more family problems (β=.54). Dehydroepiandrosterone reactivity predicted more negative emotionality later in adolescence (β=.47).
McLaughlin et al. (2014)	168 (56% Female), mean age = 14.9	CO and TPR measured during speech task (Cross-sectional)	Childhood maltreatment and externalising symptoms associated with lesser CO (β=-.50) and increased TPR (β=.49).
Natsuaki et al. (2009)	216 (51% Female), mean age = 13.3	Cortisol sampled during social performance (Cross-sectional)	Heightened stress reactivity explains how early maturation predicts symptoms of depression and anxiety in girls (R^2=.27).
Paysnick and Burt (2015)	66 (60% Female), mean age = 16.6	SCR and RSA during social competence interview. (Cross-sectional)	Baseline SCR associated with non-productive coping (r=.26). Positive association between SCR and externalising symptoms in participants who engaged in non-productive coping strategies.
Sontag et al. (2008)	111 Females, mean age = 11.8	RSQ. Cortisol during cognitive tests, cold pressor tests and interactions with mother. (Cross-sectional)	Higher cortisol reactivity in early maturing girls (partial $\eta 2$=0.04). Cortisol reactivity associated with greater self-reported arousal (r=.27).
Spies et al. (2011)	70 (55% Male), mean age = 15.3	Cortisol during parent-child conflict discussion (Cross-sectional)	Internalising symptoms associated with lower reactivity (β=-.32).

Note: APES = Adolescent perceived events scale (Compas, Davis, Forsythe, & Wagner, 1987); BP = Blood pressure; CO = Cardiac output; HR = Heart rate; MDD = Major depressive disorder; RSA = Respiratory sinus arrhythmia; RSQ = Responses to stress questionnaire (Connor-Smith, Compas, & Wadsworth, 2000); SAA = Salivary alpha amylase; SCR = Skin conductance response; TPR = Total peripheral resistance

2.3. Results

The number of participants in the studies ranged from 56 to 315 (mean = 125.42, *SD* = 74.59). The mean age in years of participants in the studies ranged from 11.84 to 16.6 (mean = 13.72, *SD* = 1.72). The percentage of males in the studies ranged from zero to 100% of the samples (mean = 46.25, *SD* = 26.37). The percentage of females in the studies ranged from 0 to 100% of the samples (mean = 53.75, *SD* = 26.37). The following section details the measures used to assess SR in the selected studies and the long-term outcomes associated with each category of measurement.

2.3.1. Measures of SR

In order to provoke stress responses in participants, the majority of studies would firstly employ stress induction protocols. These involved several different lab-based procedures. These protocols are reviewed first, followed by the measures of SR employed by the studies. The measures used to assess individual differences in SR in the chosen studies are separated into three categories: Neuroendocrine, physiological, and self-report. Two studies used multiple measures from two different categories.

2.3.1.1. Stress protocols. One of the most common protocols used in the selected studies was an evaluated speech task (Allwood, Handwerger, Kivlighan, Granger, & Stroud, 2011; McLaughlin, Sheridan, Alves, & Mendes, 2014; Natsuaki et al., 2009), most often based upon the Trier Social Stress Test (Kirschbaum et al., 1993), where participants are given a set time to prepare a speech to a panel of confederates as part of an interview scenario.

Another common protocol, that was particularly relevant for adolescent samples, were parent-child conflict tasks (Granger, Weisz, & Kauneckis, 1994; Sontag, Graber, Brooks-Gunn, & Warren, 2008; Spies, Margolin, Susman, & Gordis, 2011), where participants, along with a chosen parent, were asked to discuss a chosen topic likely to provoke conflict between the two (household chores, homework, curfews). The 'Social Competence' protocol was also used in more than one study (Colich, Kircanski, Foland-Ross, & Gotlib, 2015; Dobkin, Tremblay, & Treiber, 1998; Paysnick & Burt, 2015), where participants were asked to re-call in vivid detail a stressful or traumatic experience.

Cold pressor tasks were used to provoke stress responses by having participants immerse a hand in ice-cold water for a specified period of time, with one variant of the protocol involving participants having to maintain their gaze at a video camera said to be 'evaluating' them (Lopez-Duran et al., 2015; Sontag et al., 2008). Challenging cognitive or mental arithmetic tasks were also employed (Allwood et al., 2011; Colich et al., 2015; Sontag et al., 2008), as well as a mirror tracing task (Allwood et al., 2011).

One study involved a peer rejection task (Allwood et al., 2011), where age-matched confederates deliberately ignored and rejected participants during a social interaction task. Finally, stress responses were provoked in one study through a venepuncture procedure (i.e., having participants give blood) (Marceau, Dorn, & Susman, 2012). In summary, a wide range of different stress manipulations are adopted in studies varying in specificity to adolescents and particular types of stressor. Once conditions are manipulated to provoke stress, response systems are then examined using a number of different measures.

2.3.1.2 Neuroendocrine measures. Most of the chosen studies (eight out of twelve) used neuroendocrine measures to index responses of the HPA. All of the studies employing neuroendocrine measures assessed cortisol, indicating reactivity of the HPA (Allwood et al., 2011; Colich et al., 2015; Granger et al., 1994; Lopez-Duran et al., 2015; Marceau et al., 2012; Natsuaki et al., 2009; Sontag et al., 2008; Spies et al., 2011). A single study also measured reactivity of puberty-related hormones (testosterone and dehydroepiandrosterone, along with cortisol) which also indicate reactivity of the HPA (Marceau et al., 2012).

2.3.1.3. Physiological measures. Four out of the twelve studies used physiological measures to assess reactivity of the autonomic nervous system. One study used a range of different physiological measures to index autonomic activation: heart-rate, blood pressure, and salivary alpha amylase (Allwood et al., 2011). Heart-rate reactivity measured the increase in beats per minute throughout a task (Allwood et al., 2011). Blood pressure reactivity assessed increases in systolic and diastolic pressure throughout a task indicating reactivity, and was also used as a single measure in one other study (Dobkin et al., 1998).

One study measured both skin-conductance responses and respiratory sinus arrhythmia (Paysnick & Burt, 2015). Skin conductance indicates activation of the sympathetic nervous system through increased sweat gland activity and electrical conductance of the skin. Respiratory sinus arrhythmia is the natural variation in heart rate that occurs through a respiratory cycle. Greater parasympathetic nervous system activation leads to greater heart-rate variability. One study measured cardiac output and total peripheral resistance to index challenge and threat responses in accordance with biopsychosocial model of challenge and threat (McLaughlin et al., 2014). The biopsychosocial model (Blascovich, 2008) proposes that challenge responses to stress are indexed by increases in cardiac output coupled with decreased total peripheral resistance (allowing for increased blood perfusion, aiding performance and promoting approach to a stressor). Threat responses on the other hand, involve decreases in cardiac output along with increases in total peripheral resistance (leading to restricted blood perfusion, impairing performance and promoting withdrawal from a stressor). It is worth noting that the majority of studies examined responses of single systems (i.e.

either the HPA or the autonomic nervous system) rather than use multiple measures to assess both systems.

2.3.1.3. Self-report. Charbonneau et al. (Charbonneau, Mezulis, & Hyde, 2009) used a shortened version of the Adolescent Perceived Events Scale (Compas, Davis, Forsythe, & Wagner, 1987). This shortened version of the scale involves participants identifying which stressful events they have experienced in the last 12 months from a 59-item checklist (e.g., fights with parents, being pressured by friends, problems with a family member). Participants subjectively rate how positive or negative each chosen event was on a Likert scale, giving a score of their subjective 'emotional reactivity'. Sontag et al. (Sontag et al., 2008) employed the Responses to Stress Questionnaire (Connor-Smith, Compas, & Wadsworth, 2000). This scale is adapted to measure responses to specific stressors. In their study, it was adapted to measure responses to peer stress amongst adolescent girls. The scale measures voluntary responses (primary and secondary appraisal and coping strategies employed), involuntary engagement (rumination, intrusive thoughts, physiological arousal, emotional arousal, and involuntary action) and involuntary disengagement (emotional numbing, inaction, and escape). This measures a participant's typical engagement or disengagement response to a specific stressor. The selected studies in this review then used these measures of individual differences in SR (neuroendocrine, physiological, and self-report) to predict long-term outcomes relating physical health, subjective well-being, and social functioning.

2.3.2. Long-term outcomes

Most of the long-term outcomes reported in the chosen studies centred on internalising and externalising symptoms. Internalising symptoms broadly refer to problems of withdrawal, negative emotionality, depression, and anxiety in adolescents, while externalising refers to aggressive and disruptive behaviour exhibited by adolescents. These outcomes are reported below in relation to the three different categories of SR measurement.

2.3.2.1 Neuroendocrine measures. Three studies found higher neuroendocrine reactivity (cortisol, testosterone, and dehydroepiandrosterone) to be associated with internalising symptoms in adolescents (Allwood et al., 2011; Granger et al., 1994; Lopez-Duran et al., 2015). A further study examined the effect of maturational processes on the relationship between internalising symptoms and SR, with the association between the two only being evident in early maturing females (Natsuaki et al., 2009). Another study found greater SR in adolescents to predict the onset of major depressive disorder in later life, but not during adolescence itself (Colich et al., 2015). These findings would suggest that neuroendocrine reactivity is associated with internalising symptoms during adolescence and depression later in life, and that early maturing females were most likely to develop internalising symptoms because of high SR. However, despite these findings, two studies found no support for the association between neuroendocrine reactivity and internalising symptoms (Marceau et al., 2012; Sontag et al., 2008).

2.3.2.2. Physiological measures. While neuroendocrine responses were mostly related to internalising symptoms (with some contradictory findings), physiological measures of SR were more closely related to externalising symptoms. One study found an association between low physiological reactivity (heart-rate and blood pressure) and externalising symptoms (Dobkin et al., 1998; McLaughlin et al., 2014). One study produced conflicting results, with *greater* physiological reactivity (skin conductance response) being associated with externalising symptoms. However, this association was only evident in participants who engaged in non-productive coping strategies (Paysnick

& Burt, 2015). Taking a unique approach compared to the other studies, one study measuring challenge and threat responses found externalising symptoms to be associated with a threat response to stressors (a decrease in cardiac output and increase in total peripheral resistance; McLaughlin et al., 2014). Aside from externalising symptoms, a study found *baseline* salivary alpha amylase (but not reactivity) to be associated with trait anxiety (Allwood et al., 2011).

2.3.2.3. Self-report measures. Self-reported reactivity acted as mediators between reported stress and internalising symptoms (Charbonneau et al., 2009; Sontag et al., 2008). Charbonneau et al. (2009) noted a stronger relationship between perceived stress and depressive symptoms when levels of self-reported emotional reactivity were higher than average. Individual differences in self-reported involuntary engagement (reactivity in the form of rumination, intrusive thoughts, physiological arousal, emotional arousal, involuntary action in response to a stressor; measured with the Responses to Stress Questionnaire) mediated the positive relationship between peer stress and internalising symptoms (Sontag et al., 2008).

2.4. Summary and discussion

2.4.1. Measuring SR

In terms of methodologies, the review found a wide range of different measures of SR utilised in research with adolescents. Most of these were neuroendocrine and physiological; self-report measures were less prevalent. Of the studies that used stressor manipulations to provoke these responses, some studies used single scenarios (i.e., social conflict provoking discussions with parents), whilst others used multiple procedures replicating different stressors (i.e., socially evaluative speech tasks followed by difficult arithmetic or cognitive tasks, and cold pressor tests). Some, but not all, of the stress protocols were relevant to adolescent populations (e.g., parent child conflict discussion task). However, other studies relied upon more generic stress protocols that would also be used with adults, such as cold pressor tests or arithmetic tasks.

The use of different measures, and combinations of measures, paint an inconsistent picture of how to measure adolescents' individual differences in SR. Whether using single or multiple measures, none of the studies used an approach which aggregated SR across stressors. Furthermore, many studies, rather than referring broadly to SR, referred to specific types of reactivity, such as 'cortisol reactivity' or 'blood pressure reactivity'. One could argue that measuring a single physiological response to single stressors or situations lacks ecological validity. As Schlotz (2013) stated "It is not possible to use the stress response in one domain or system as a general indicator of responses in another domain" (p. 1892). Due to stimulus response specificity, individuals respond differently to different stressors (e.g., social stress vs. workload). Therefore, if individual differences in SR were to be explored further in sporting contexts with adolescents, one must consider whether to measure and refer to a specific index of reactivity (e.g., cortisol reactivity), or whether to use measures that can aggregate individual differences in responses across systems and stimuli to produce a broad aggregated measure of SR. That said, to use a range of different neuroendocrine and physiological measures with multiple different stressor manipulations would likely be highly impractical, time-consuming, and costly.

Self-report measures would overcome these obstacles but appear to be underutilised within this field of research. Furthermore, the self-report measures in selected research refer to specific stressors experienced by adolescents in general, rather than broader categories or domains that could be applied to sporting contexts. However, the Perceived Stress Reactivity Scale (PSRS; Schlotz, Yim, et al., 2011), which was not featured in the reviewed literature, assesses perceived reactivity to different stress domains (i.e.; reactivity to failure, reactivity to social evaluation, reactivity social conflict, reactivity to work overload, and prolonged reactivity). On the other hand, the PSRS is not designed for use with adolescents; hence it was not a featured measure in this review. Therefore, it is perhaps more pragmatic to develop a sport-specific self-report measure of SR by adapting a pre-existing measure such as the PSRS.

A self-report measure could capture an individual's typical perceived reactions to different types of stress applied within the context of sports competition and participation, thus creating a broad aggregated measure of SR. Furthermore, considering that Lazarus and Folkman (1987) proposes that stress emerges from the subjective appraisal of potentially stressful events, a measure of perceived reactivity would sit well within such a framework, as it would subjectively assess an individual's typical reactions to different stress domains. This could provide a useful alternative to lab-based assessments, although not a complete replacement given the biases associated with self-report questionnaires (such as social desirability bias; Furnham, 1986). Although the PSRS has been found to be associated with cortisol reactivity (Schlotz, Hammerfald, et al., 2011), there have also been equivocal findings with regards to the association between self-reported reactivity, and physiological and neuroendocrine measures (Evans et al., 2013). Overall, future research should clarify which methods (social stress tests, physical tasks, cognitive tasks, or re-call) and measures (neuroendocrine, physiological, or self-report) are most valid and reliable for assessing SR in adolescent athletes.

2.4.2. Long-term outcomes

High neuroendocrine and self-reported reactivity was associated with internalising symptoms (withdrawal, negative emotionality, anxiety, and depression) in adolescents.

Physiological reactivity was associated with externalising symptoms (aggressive and disruptive behaviour), however the direction on the relationship is unclear due to equivocal findings. The role of gender and maturational processes are also unclear. Given the high volume of stressors experienced by adolescent athletes, SR hyper-reactivity could pose a significant risk factor for young people competing in sporting environments. Within Lazarus and Folkman's (1987) model transactional model, SR could prove to be stable personal factor influencing the stress, emotions, coping, and performance of adolescent athletes. Individual differences and stress have been identified as significant correlates of burn-out and drop-out in both youth and adult sport (Crane & Temple, 2015; Goodger et al., 2007). Burn-out can have a significant detrimental impact upon the development of young athletes, with many who experience it choosing to withdraw from their sport participation as a result (Smith, 1986). Future research could look to further examine whether SR influences the stress and coping process of adolescent athletes.

It must be noted that the majority of the studies measured their outcomes using a cross-sectional, rather than longitudinal, design. In fact, only two of the studies used longitudinal measures to examine the effect of SR on outcomes later in life or across a period of time (Colich et al., 2015; Marceau et al., 2012). Therefore, if future research were to examine SR's relationship with the outcomes experienced by youth athletes (such as well-being), the use of more longitudinal designs could be considered. Given the large number of different stressors young athletes experience, a longitudinal design could explore the role SR plays in how different stressors are appraised, coped with, and the resulting emotions and other outcomes experienced.

One might conclude that adolescent athletes with low SR should be sought after, as they are more likely to cope adaptively with the demands of competitive sport during their youth and in later life. However, there is evidence to suggest low physiological reactivity is associated with externalising symptoms. On the other hand, there was also evidence to suggest that *high* physiological reactivity is associated with externalising symptoms, along with threat response patterns. Therefore, conclusions regarding physiological reactivity and its association with externalising symptoms should be treated with caution and should be subject to further clarification in future research.

With regards to gender and developmental factors, mixed and inconsistent results make it difficult to draw any conclusions. From the selected studies, it is unclear as to whether early or late pubertal maturation in adolescence is associated with greater SR, and how this later impacts on the development of internalising or externalising symptoms. This, therefore, could be investigated further in a sporting context, with prior research having already examined the effects of pubertal, cognitive and emotional maturation on stress appraisal and coping of adolescent athletes (Nicholls et al., 2015; Nicholls et al., 2013; Nicholls et al., 2009). Most studies which examined gender differences found females to have higher levels of SR, with one study reporting higher peak cortisol levels in males (Lopez-Duran et al., 2015). This would suggest that, overall, female adolescent athletes would be more likely to have higher SR than males. Despite this, further research applying the concepts of individual differences in SR to adolescents sporting contexts is needed to draw any further conclusions on gender differences and developmental factors.

2.4.3. Limitations

During the process of conducting this systematic review, it was observed that the term ‘stress reactivity’ is often applied with inconsistent terminology, particularly in relation to whether SR is a stable individual difference, or a state measure of an observed or manipulated stress response. Many studies were also excluded because they did not examine the long-term outcomes associated with SR but focussed instead on the developmental factors contributing to SR. This, therefore, made defining the search criteria for a literature review such as this problematic. It is also possible that many excluded studies may have assessed stable individual differences in responses to stress without the use of the term ‘stress reactivity’. Therefore, the limited number of selected studies may not reflect all research in this area, and thus all the associated measures and outcomes of adolescent SR. Future research may wish to resolve these issues by consistently operationalising stable individual differences in stress responses as ‘stress reactivity’.

Some studies referred to measuring a specific type of reactivity (such as ‘cortisol reactivity’ or ‘blood pressure reactivity’) while other referred to ‘stress reactivity’ more broadly. It is clear from the reviewed literature that there are many types of ‘stress reactivity’, depending upon the index of measurement being used. Furthermore, it appears that certain outcomes are more associated with different types of reactivity than others (e.g., neuroendocrine responses being associated more closely with internalising symptoms). Therefore, an alternative solution would be for future research to be specific with the index or type of SR being examined, rather than the use of the broad terminology ‘stress reactivity’.

2.4.4. Conclusions

SR potentially plays a key role in an adolescent’s interaction with stressors, as a stable individual difference influencing the development of internalising and externalising symptoms. Within a sporting context, SR is yet to be applied as an individual difference influencing the development of adolescent athletes. However, the methods used to measure SR as a stable individual difference in the wider literature are limited. There is an over-reliance on the measurement of single neuroendocrine or physiological responses during lab procedures. These lack the ecological validity of real world responses to sporting environments. Therefore, the measures reviewed in this chapter are arguably not appropriate for meeting the aims, objectives, and predictions of this thesis.

Future research could look to develop sport specific measures of SR that reflect the situations experienced by adolescent athletes. There may be benefits in adapting a self-report measure of SR that could better reflect the specific stressors experienced by adolescent athletes in sporting contexts (A1, O1). However, the self-report measures reviewed here are also problematic for use within sporting contexts, as they measure reactivity to specific stressors that cannot be directly applied to sporting contexts. Therefore, a self-report measure of SR that features broader stress domains that can be applied to sporting contexts (such as the PSRS by Schlotz and colleagues) could be adapted to meet the aims, objectives, and predictions of this thesis. Such a measure of perceived reactivity would fit well within Lazarus and Folkman's appraisal-based models of stress and coping.

Hyper-reactivity is associated with internalising symptoms, negative emotionality, depression, anxiety, and social withdrawal during adolescence and in later life. These outcomes would have a significant impact upon the psychological well-being of adolescents participating in competitive sport (A2). However, the majority of studies used cross-sectional designs to assess the relationship between SR and long-term outcomes, rather than longitudinal designs to examine its effects on outcomes over time. More valid conclusions could be drawn from future research if it were to employ longitudinal designs to examine the effect of SR on adolescent athletes' health and well-being over time. Overall, further research is required to greater understand the effect of SR individual differences on adolescent athletes, particularly in relation to their psychological well-being. Furthermore, there appear to be different outcomes associated with different indexes of SR, placing significant importance on the index or construct of SR used when examining specific outcomes. This greater understanding could pave the way for practitioners to better help adolescent athletes cope with the stressors they experience, thus potentially enhancing youth their wellbeing and performance, and reducing levels of burnout and dropout.

Chapter 3. The Perceived Stress Reactivity Scale for Adolescent Athletes

The systematic review conducted in chapter 2 revealed several limitations for the methods used to assess adolescents' individual differences in SR if they were to be applied to sporting contexts. Mainly that the neuroendocrine and physiological indexes obtained from controlled laboratory procedures lacked the ecological validity to reflect SR experienced in sporting contexts. Also, such laboratory assessments are considered costly, time-consuming, and potentially invasive. Furthermore, chapter 2 revealed that there were different outcomes associated with different indexes and constructs of SR. Therefore, this study aims to adapt an existing self-report measure of perceived SR (The Perceived Stress Reactivity Scale; Schlotz, Yim, et al., 2011) for use with adolescent athletes (A1). This is achieved by performing a confirmatory factor analysis on the adapted scale with a sample of adolescent sportspeople, and exploring its criterion validity in relation measures of perceived stress, personality, and subjective wellbeing (O1).[1]

3.1. Introduction

Adolescent athletes experience a great number of stressors, including competitions, regular social evaluation and criticism, family and peer influences, as well as academic commitments (Compas et al., 2001; Nicholls et al., 2005; Reeves et al., 2009; van Rens et al., 2016). When faced with a stressor, an initial activation of the autonomic nervous system (ANS) and the hypothalamic-pituitary-adrenal (HPA) axis prepares an individual for action and facilitates a process of appraisal and coping responses.

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[1] Britton, D., Kavanagh, E., & Polman, R. (2017). The Perceived Stress Reactivity Scale for adolescent athletes. *Personality and Individual Differences*, *116*, 301-308.

Lazarus and Folkman proposed in their transactional model of stress and coping that the appraisal of a stressor consists of numerous judgments regarding its threat or challenge to the individual, its potential benefit, harm or benignity, and the individual's perceived control (see Figure 1; Lazarus & Folkman, 1987). This in turn influences the choice of coping strategy selected. Athletes have been found to use a vast variety of different coping strategies (Nicholls & Polman, 2007). A problem focussed strategy involves directly addressing the source of stress to nullify it whereas an emotion focussed strategy regulates one's own emotions in response to a stressor. Finally, an avoidance focussed strategy aims to physically or psychologically disengage or distance oneself from the source of stress and one's emotional response (Lazarus & Folkman, 1987). Being unable to cope adaptively with these stressors, and thus stem the activation of the ANS and HPA, can lead to athletes experiencing unpleasant emotions (such as anxiety, anger, shame or guilt) and can result in reduced satisfaction with their performance (Lazarus, 2000; Nicholls et al., 2012). Moreover, stress has been cited as a significant cause of both athlete burnout and dropout (Crane & Temple, 2015; Goodger et al., 2007; Smith, 1986).

Lazarus and Folkman (1987) proposed that numerous personal and situational factors can directly and indirectly influence the stress and coping process (see Figure 1). For example, gender (Kaiseler et al., 2012b), the Big Five personality traits (Kaiseler et al., 2012a), mental toughness (Kaiseler et al., 2009), and pubertal, cognitive, and emotional maturity (Nicholls et al., 2015; Nicholls et al., 2013; Nicholls et al., 2009) have all been associated with differences in appraisal and coping responses to stress in athletes. Therefore, individual differences can be examined to predict the likelihood of performance and well-being related outcomes in sport. This is of great importance in youth sport, given the vast number of stressors experienced by adolescent athletes during their development. However, little research within sporting contexts has examined the biological basis underpinning these individual differences or considered differential sensitivity of the ANS and HPA as an individual difference in and of itself. In other words, individual differences in stress reactivity (SR).

3.1.1. Stress reactivity

SR has been defined as an individual difference underlying variability in physiological and psychological responses to stress (Boyce & Ellis, 2005; Ellis et al., 2005; Schlotz, 2013; Schlotz, Hammerfald, et al., 2011; Schlotz, Yim, et al., 2011). It has been proposed that there is a biological basis to personality, with traits such as neuroticism and extraversion being the result of differential levels of reactivity to environmental stimulation (Suls & Martin, 2005). Exposure to stress and adversity during early childhood has been associated with the development of maladaptive levels of SR later in life. (Boyce & Ellis, 2005; Hughes et al., 2017). However, it has been argued that adolescence is also a critical period where SR is developed, with the protracted maturation of the brain increasing sensitivity to stressors (Romeo, 2010).

Hyper-reactivity in adolescents has been associated with internalising symptoms (negative emotionality, anxiety, and depression; Allwood et al., 2011; Granger et al., 1994; Lopez-Duran et al., 2015). Therefore, SR could have a critical effect on whether adverse outcomes (such as anxiety and depression) are developed by young sportspeople in the face of this vast number of stressors they are known to experience. Adolescence may then be an ideal window of opportunity for providing interventions to young athletes, particularly those who can be identified as having high SR. This therefore raises the question of how SR should be measured in adolescent athletes.

It has been commented that SR would be difficult to measure and assess in athletic contexts (Polman et al., 2010). To date, SR in adolescents has been examined using various physiological (e.g., heart rate variability, cardiac output, blood pressure, skin conductance) and neuroendocrine measures (e.g., cortisol) in controlled lab-based procedures (Allwood et al., 2011; Colich et al., 2015; Marceau et al., 2012; McLaughlin et al., 2014; Paysnick & Burt, 2015). However, in more ecologically-valid athletic situations, differences in an observed stress response may be influenced by several situational factors, not just personal factors related to SR. It may also be difficult to delineate between physiological arousal as a consequence of SR or of the physical demands of sport (Polman et al., 2010). Stressor specificity also affects the validity of one-time lab-based methods of measuring SR as a stable factor (Schlotz, Yim, et al., 2011). For example, HPA reactivity has been associated closer with responses to social stress, while ANS reactivity has been primarily related to arousal and effort (Schlotz, 2013; Schlotz, Yim, et al., 2011). Unless measurements are repeated extensively under different environmentally controlled conditions using multiple measures, which would be costly and time-consuming (Schlotz, Yim, et al., 2011), a self-report measure would be more practical and ecologically valid.

3.1.2. The construct of perceived stress reactivity

A solution to these methodological difficulties could be found in the construct of perceived stress reactivity (PSR). Scholtz et al. (2011) developed the Perceived Stress Reactivity Scale (PSRS), a self-report questionnaire which measures a person's typical stress responses to different generalised situations, creating an aggregate score for an individual's 'total reactivity'. PSR has been defined as 'a disposition that underlies individual differences in physiological and psychological stress responses' (Schlotz et al., 2011, p. 81). Given that Lazarus and Folkman's transactional model proposes that stress responses are the result of the subjective appraisal of potentially stressful situations, the construct of PSR fits well within this theory. However, it must be noted that a measure of PSR would not be a complete replacement for neuroendocrine or physiological measures. Although the PSRS has been found to be associated with cortisol reactivity (Schlotz, Hammerfald, et al., 2011), there have also been equivocal findings testing the association between self-reported reactivity, and physiological and neuroendocrine measures (Evans et al., 2013).

Scores from the PSRS have already been associated with self-efficacy, neuroticism, chronic stress, perceived stress, depressive symptoms, sleep quality, threat appraisals, and increased cortisol responses to social evaluation (Schlotz, Hammerfald, et al., 2011; Schlotz, Yim, et al., 2011). However, the PSRS would need to be adapted to represent stress response domains within the context of adolescent athletes and youth sport. For example, items referring to reactivity to social evaluation would need to refer to the socially evaluative situations experienced by adolescent athletes (e.g. performing in front of other people, their performance being evaluated by coaches).

3.1.3. The present study

Study 1 aimed to adapt the PSRS and validate it for measuring PSR in adolescent athletes (The Perceived Stress Reactivity Scale for Adolescent Athletes; PSRS-AA). This was to explore the validity of the PSRS-AA as a potential predictor of performance and well-being related outcomes for future research and applied practice in sporting contexts (A1). This study evaluated the relationship between the PSRS-AA and other self-report measures of perceived stress, personality, and subjective well-being (O1), as well as the questionnaire’s fit to its original five-factor model. It was predicted that the five-factor model structure of the original PSRS would fit that of the adapted scale for adolescent athletes. It was hypothesised that the PSRS-AA would positively correlate with perceived stress, would negatively correlate with emotional stability on a personality inventory and would negatively correlate with subjective well-being on a measure of life satisfaction. It was also hypothesised that adolescent girls would score higher on the PSRS-AA than adolescent boys.

3.2. Method

3.2.1. Participants

243 adolescent student athletes (in full time education and competing in one or more sports) were recruited from several schools, colleges, academies, and universities to complete a battery of self-report questionnaires either electronically or on paper (age 12-22 years, *M* age = 16.46, *SD* = 2.93). A university ethics board approved ethical clearance. Consent was obtained from a parent or guardian of all participants under the age of 16. 61.3% Of the recruit participants were male (*N* = 149), while 38.7% were female (*N* = 94).

Participants were asked to name their first sport (the sport they competed in the most) and identify their level of competition at both junior and senior level (see Table 1). 29 Sports were named as the participants' first choice activity. 37.9% of participants competed in a second sport at junior level (26 additional sports were named). 13 participants completed the PSRS-AA again approximately 4 weeks later to examine its test re-test reliability (62% Male; 38% Female).

3.2.2. Measures

3.2.2.1. The perceived stress reactivity scale for adolescent athletes.

The original PSRS consists of 23 items with five subscales (reactivity to social evaluation, reactivity to failure, reactivity to social conflicts, reactivity to work overload, and prolonged reactivity). Each item presents a potentially stressful stimulus (e.g. 'when I argue with other people') and offers a choice of three descriptive responses for the participant to choose from (e.g. 'I usually calm down quickly, 'I usually stay upset for some time' or 'It usually takes me a long time until I calm down'). Responses are coded on a scale of zero to two, with the answer representing the least reactivity scoring zero, and the answer representing the most reactivity scoring two. The sum of the mean scores on each subscale indicates an individual's 'total reactivity' (Appendix 1).

Table 2: Participants' Highest Levels of Competition at Junior and Senior Level (%).

Age Level		%
Junior Level (First sport)	Currently injured or suspended	9.9
	Local club or school	30.9
	County	25.9
	Regional	13.2
	National	16.5
	International	3.7
Junior Level (Second sport)	Do not compete in a second sport at junior level	62.1
	Currently injured or suspended	0.4
	Local club or school	19.8
	County	9.9
	Regional	5.3
	National	2.1
	International	0.4
Senior Level (First sport)	Do not compete in first sport at senior level	23.5
	Currently injured or suspended	1.6
	Local club	40.7
	County	11.1
	Regional	10.7
	National	11.1
	International	1.2
Senior Level (Second sport)	Do not compete in a second sport at senior level	80.6
	No competition	0.8
	Local club	12.8
	County	2.1
	Regional	2.5
	National	1.2

The instructions of the PSRS were adapted to instruct participants to reflect upon their reactions to stressful situations related to their participation in sport, rather than stressful situations in general. The wordings of the items in the PSRS were adapted to reflect sport-specific versions of the stress stimuli described in each item where appropriate. For example, "When I want to relax after a hard day at work" was re-worded to "when I want to relax after a hard training session". However, some items were not required to be re-worded, such as “when I make a mistake”. Two external researchers with experience in questionnaire development and sport psychology firstly checked content validity. This was to assess both the scale’s appropriateness for measuring PSR , and for its appropriateness to be administered to adolescent participants, with suggested changes being made to the scale. Two participants within the target sample were then recruited (with ethical clearance approved by a local ethics board) and asked to read the questionnaire. The participants were asked to feedback on any items or elements of the instructions which were unclear or difficult to understand.

Finally, a Flesch-Kincaid grade level test was run to estimate the reading proficiency needed to understand the items. This uses a formula which considers sentence length and the average number of syllables per word, to calculate the school grade required to understand a selected text. Item wordings were adapted to require the minimum reading age of the target sample (12 years of age). This ensured that the PSRS-AA would be understood by the youngest of reading ages within the sample. After this process, the PSRS-AA retained its 23-item structure, with five factors (social evaluation, work overload, social conflict, failure, and prolonged; Appendix 2).

3.2.2.2 Perceived stress scale. The perceived stress scale (PSS; Cohen, Karmack, & Mermelstein, 1983) is a 10-item self-report questionnaire, designed to measure how much an individual perceives events in their life over the past month as being uncontrollable, overwhelming and unpredictable, thus indicating their level of perceived stress during that time (e.g., “In the last month, how often have you felt that you were unable to control the important things in your life?"; Appendix 3). Participants rate the frequency of each item in their lives on a 5-point likert scale. The scale has demonstrated good internal consistency (α =.85) and validity through correlations with the impact of stressful life events and depressive symptomology (Cohen et al., 1983).

3.2.2.3 Ten item personality inventory. The ten item personality inventory (TIPI; Gosling, Rentfrow, & Swann, 2003) measures the "Big Five" personality traits (extraversion, agreeableness, conscientiousness, emotional stability, and openness; Appendix 4). Each trait is measured with two items. Participants are asked to rate the extent to which a pair of words describes them on a 7-point likert scale. This measure was selected as a very brief alternative measure of the big five personality traits. The TIPI correlates strongly with the Big Five Inventory (r =.77) (Gosling et al., 2003).

3.2.2.4 Brief measure of student life satisfaction scale. The brief measure of student life satisfaction scale (BMSLSS; Athay, Kelley, & Dew-Reeves, 2012) is a measure of subjective well-being (Appendix 5). Students rate the extent to which they are satisfied with their family life, friendships, school experience, themselves, where they live, and their life overall, on a 5-point likert scale. The mean score across these six domains indicates their total life satisfaction and thus their subjective well-being. The scale demonstrates adequate internal consistency (α =.77) and one factor model fit (Athay et al., 2012). For the present study, an additional life domain was added to the measure: "sport experience" (see van Rens et al. 2016). Participants rated on the same likert scale their satisfaction with their sport experience. This score was summed along with the scores in the other life domains and divided by seven to give the mean life satisfaction score.

3.2.3. Analysis

Confirmatory factor analyses (CFAs) based on maximum likelihood estimation and a co-variance matrix were conducted using SPSS AMOS (v. 23). 200 cases is often considered, as a rule of thumb, a minimum requirement for CFA (Kline, 1998). This was achieved with the recruitment of 243 participants. A second order model was used to test the data from the PSRS-AA's fit to the original five factor structure of the PSRS (Bryne, 2016). Lambda was set to 1 for each first observed indictor of the latent variables and the error weights, with all other parameters being freely estimated. The goodness-of-fit indices used to determine model fit were as follows: (1) Chi squared/degrees of freedom (CMIN/DF; less than 3 indicating an acceptable fit; Kline, 1998), (2) comparative fit index (CFI; greater than or equal to .95 indicating a good fit and .90 indicating an adequate fit; Hu & Bentler, 1999) and root mean square error of approximation (RMSEA; less than .06 indicating a good fit; Hu & Bentler. 1999), plus the *p* value testing the null RMSEA (PCLOSE; a non-significant result greater than .05 to reject the null), were all assessed to measure the model's fit (Hu & Bentler, 1999).

Model modification was carried out using modification indices, factor loadings (with values greater than or equal to .34 being considered acceptable), and drawing of co-variances between correlated errors supported by a strong rationale, such as clear item content overlap, and the replication of error co-variances from previous research (Byrne, 2016). Cronbach's alpha scores were calculated to test the PSRS-AA's internal consistency within its subscales and its total reactivity scores (.60 to .69 being questionable, .70 to.79 being acceptable, and .80 and above being good; Kline, 1999). Test re-test reliability was calculated using intraclass correlation coefficients (ICCs) between scores approximately four weeks apart and the sub-sample of participants (ICCs greater than .81 classified as excellent, .60 to .80 as good, .41 to .60 as moderate, and less than .40 as poor; Nunnally & Bernstein, 1994). Construct validity of the PSRS-AA was tested using Pearson's *r* correlations with the PSS, TIPI, and BMSLSS (*r* correlations from .10 to .29 being classified as small, .30 to .49 medium, and .50 and above large). Gender differences in scores on the subscales and total reactivity were also analysed using independent samples *t* tests with effect sizes (Cohen's *d*; .20 to .49 being classified as small, .50 to .79 medium, and .80 and above as large).

3.3. Results

3.3.1. Confirmatory factor analysis

Initial analysis using a five-factor second order model produced an unacceptable level of fit (CMIN/DF = 1.59; CFI = .89; RMSEA = .05; PCLOSE = .55). The modification indices provided by AMOS indicated that items 2 and 10 were highly correlated. The content of these two items shared clear content overlap (item 2: *When I want to relax after a hard training session or match: This is usually quite difficult for me; I usually succeed; I generally have no problem at all*; item 10: *When I have spare time after training or playing hard: It is often difficult for me to relax; I usually need some time to relax properly; I am usually able to relax well*) plus this was a replication of a same error co-variance featured in the confirmatory factor analysis of the original PSRS. Therefore, co-variances were drawn between these two items. The resulting analysis provided an acceptable fit to the five-factor structure (CMIN/DF = 1.43; CFI = .92; RMSEA = .04; PCLOSE = .90; see Figure 3).

3.3.2 Internal consistency and test re-test interclass correlation

Cronbach's alpha scores indicated good internal consistency for the measure of total reactivity, while scores for the individual subscales ranged from acceptable to questionable (see Table 3). ICCs indicated that the measure of total reactivity had good test re-test reliability. The reliability of the subscales ranged from good to moderate (see Table 3).

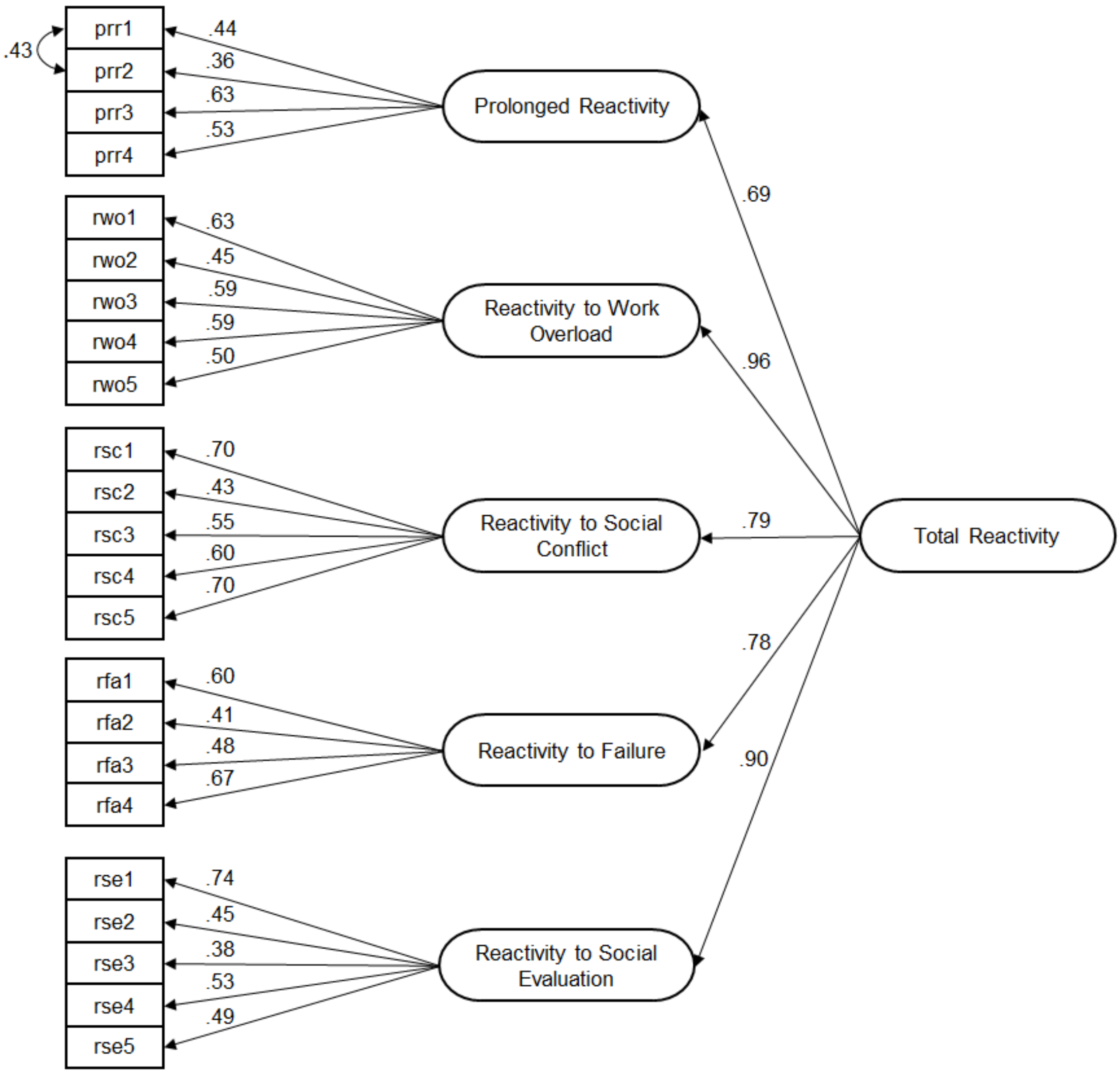

Figure 4: Confirmatory factor analysis of the PSRS-AA using second order hierarchical model

Table 3: Internal Consistency (Cronbach's α) and Test–Retest ICCs of Perceived Stress Reactivity scale for adolescent athletes.

Scales	α	ICC
Prolonged Reactivity	.62	.40
Reactivity to Work Overload	.69	.50
Reactivity to Social Conflict	.73	.68
Reactivity to Social Evaluation	.65	.65
Reactivity to Failure	.63	.52
Total Reactivity	.87	.73

Table 4: Correlations between the Perceived Stress Reactivity Scales for Adolescent Athletes and other measures.

Scales	Prolonged Reactivity	Reactivity to Work Overload	Reactivity to Social Conflict	Reactivity to Social Evaluation	Reactivity to Failure	Total Reactivity
Extraversion	-.11	-.13*	-.20**	-.25**	-.20**	-.24**
Agreeableness	-.10	-.10	-.03	.11	-.05	-.04
Conscientiousness	-.07	-.01	-.02	-.02	-.03	-.03
Emotional Stability	-.32**	-.43**	-.48**	-.43**	-.35**	-.54**
Openness	-.06	-.18**	-.18**	-.17**	-.18**	-.21**
Perceived Stress	.31**	.49**	.49**	.44**	.30**	.55**
LS Family	-.26**	-.17**	-.15*	-.16*	-.11	-.23**
LS Friendships	-.26**	-.19**	-.16*	-.20**	-.05	-.24**
LS Education	-.18**	-.23**	-.14*	-.11	-.16*	-.22**
LS Self	-.28**	-.37**	-.26**	-.34**	-.15*	-.38**
LS Location	-.29**	-.29**	-.24**	-.25**	-.20**	-.34**
LS Sport	-.15*	-.28**	-.20**	-.15*	-.16*	-.25**
LS Life	-.28**	-.28**	-.23**	-.26**	-.15*	-.32**
LS Total	-.35**	-.37**	-.29**	-.30**	-.21**	-.41**

Note. * $p < .05$. ** $p < .01$; LS = Life Satisfaction

Table 5: Gender differences in Perceived Stress Reactivity of Adolescent Athletes.

	Female		Male			
Scales	*M*	*SD*	*M*	*SD*	*t*	*d*
Prolonged Reactivity	.57	.49	.45	.41	1.88	.26
Reactivity to Work Overload	.63	.47	.43	.37	3.55**	.47
Reactivity to Social Conflict	.76	.48	.55	.43	3.45**	.46
Reactivity to Social Evaluation	.88	.50	.60	.38	4.53**	.63
Reactivity to Failure	.96	.40	.90	.43	1.19	.14
Total Reactivity	3.80	1.78	2.93	1.41	3.99**	.54

Note. * $p < .05$. ** $p < .01$

3.3.3. Construct validity

3.3.3.1. Perceived stress. A large positive correlation was found between total reactivity and perceived stress experienced in the month prior to data collection. Medium positive correlations were observed between scores on the PSS and the PSRS-AA's five subscales (see Table 4).

3.3.3.2. Big five personality traits. A large negative correlation was observed between total reactivity and emotional stability. Emotional stability also had negative medium correlations with the PSRS-AA's subscales, although lower. There were also small but significant negative correlations between total reactivity and extraversion and openness. (see Table 4).

3.3.3.3. Life satisfaction. A medium negative correlation was observed between total reactivity and total life satisfaction. On the BMSLSS's individual items, only a small negative correlation was observed between satisfaction with sport experience and scores on the PSRS-AA. Small correlations were also observed with the life domains of family and friendships. Medium correlations, however, were observed with the domains of self, location, and life overall (see Table 4).

3.3.3.4. Gender differences. Females reported greater total reactivity compared to males. An independent samples t-test revealed this difference to be significant, with a medium effect size. On the PSRS-AA's subscales, females also reported significantly higher reactivity to work overload, social conflict, and social evaluation. However, gender differences in reactivity to work overload and social conflict produced only small effect sizes. Only reactivity to social evaluation produced a medium effect size (see Table 5).

3.4. Discussion

Study 1 provides support for the use of the PSRS-AA in youth sport contexts to measure individual differences in PSR. The five-factor 23 item structure of the original PSRS provided acceptable model fit for the PSRS-AA. There was adequate internal consistency and test retest reliability for the scale's measure of total reactivity (A1). The association between the PSRS-AA and related measures of personality, perceived stress, and subjective well-being were then examined (O1). As predicted, total reactivity was positively associated with perceived stress, and negatively associated with the trait emotional stability, extraversion, openness, and with life satisfaction. Gender differences were also as expected, with females reporting higher levels of total reactivity than males. The study provides a springboard for further research related to PSR and individual differences in youth sport contexts. Furthermore, the PSRS-AA can be used as a less time-consuming, less costly, and more ecologically valid alternative to lab-based methods of assessing individual differences in SR.

Confirmatory factor analysis of the PSRS-AA's model fit to the original scale's five factor structure demonstrated adequate results. This was achieved with one co-variance drawn between items 2 and 10 of the prolonged reactivity factor. There is a clear overlap of content between these two items (i.e. the ease of recovery from stress after training or matches) and this correlation of errors was also present in the original PSRS (Schlotz, Yim, et al., 2011). This therefore can be used to justify the co-variance drawn between these two items (Byrne, 2016). This provides support for collating perceived reactivity to different stress response domains to measure overall total reactivity as a broad stable trait, and that these stress response domains can be related to sport-specific contexts in youth sport.

The PSRS-AA's relationship with perceived stress indicates that adolescent athletes who are highly reactive experience greater levels of stress over time, feeling that their lives are uncontrollable and difficult to cope with. In other words, more reactive adolescent athletes experience more stress. Furthermore, the scale's relationship with the BMSLSS indicates that PSR is associated with subjective well-being, with highly reactive adolescent athletes experiencing lesser satisfaction across life domains. However, when examining the BMSLSS's individual measures of different life domains, sport experience did not demonstrate the strongest relationship with the PSRS-AA compared to other life domains (such as education, friendships, family, and location). This would lend support to the notion that SR is a broad stable trait (Schlotz, 2013), thus influencing satisfaction and well-being across all life domains irrespective of situational factors.

The scale's relationship with the Big Five personality traits indicates that high reactors are low in emotional stability. This supports previous research which has associated neuroticism with greater perceived stressor intensity, lower perceived control, and the use of emotion and avoidance focussed coping strategies in athletes and the wider population (Connor-Smith & Flachsbart, 2007; Kaiseler et al., 2012a). A significant relationship between reactivity and low levels of extraversion was also observed. This further supports prior findings which have associated extraversion with low SR (Connor-Smith & Flachsbart, 2007). Overall, the relationship of these two traits (extraversion and neuroticism) with PSR supports the assumption that personality is associated with reactivity and sensitivity to environmental signals (Suls & Martin, 2005).

Gender differences between scores on the PSRS-AA also supported its validity in its adapted form for adolescent athletes. This supports previous research which has reported greater SR in adolescent females (Charbonneau et al., 2009; Hankin, Mermelstein, & Roesch, 2007). Furthermore, females reported higher levels of reactivity to work overload, social conflict, and social evaluation, but not prolonged reactivity or reactivity to failure. This suggests that adolescent females participating in sport experience more reactivity to social environments (such as performing in front of crowds, being evaluated by their coaches, or disagreements with teammates) and situations of high physical and psychological demand (having to manage multiple commitments in and outside of their sport). This puts greater emphasis on the management of stress in female youth sports in particular, notably in the face of stressors relating to criticism, self-presentation, inter-personal relationships with team-mates and coaches, and the management of workloads and commitments.

The internal consistency scores also indicate that the scale's items reliably contribute to form an aggregated measure of an individual's PSR. The internal consistencies of the individual subscales are somewhat lower however. One would therefore recommend that analysis which examines these subscales in isolation should be treated with caution. However, it is possible that the PSRS-AA's individual subscales relate to other specific traits, and thus may predict certain outcomes. For example, the reactivity to social evaluation subscale may relate to traits of self-consciousness, which have been linked to performance decrements under conditions of social evaluative threat (Geukes, Mesagno, Hanrahan, & Kellmann, 2013; Mesagno, Harvey, & Janelle, 2012). The reactivity to social evaluation subscale on the original PSRS has been associated with greater cortisol responses to a social stress test (Schlotz et al., 2011b). Future research may wish to explore this further. Overall though, the scale's measure of total reactivity, aggregating reactivity across response domains, demonstrates good validity, reliability, and consistency.

Future research is required to further establish the PSRS-AA for use within research and applied practice with adolescent athletes. Individual differences (Big Five personality traits and mental toughness) have been previously identified as influencing the stress appraisal and coping behaviour of athletes (Kaiseler et al., 2009; Kaiseler et al., 2012a). PSR could influence how young athletes cope with stress, and their subsequent performance and well-being, by producing greater activations of the ANS and HPA systems in response to their environment. With stress being a significant cause of burnout and dropout from youth sport (Crane & Temple, 2015; Goodger et al., 2007), PSR could predict the risk of both these outcomes. Future research could further validate the PSRS-AA by testing its association with physiological or neuroendocrine measures. Cortisol reactivity and heart rate variability have both been associated with sports performance under pressure conditions (Laborde, Lautenbach, & Allen, 2015; Lautenbach, Laborde, Klämpfl, & Achtzehn, 2015). Validation via these methods would confirm the PSRS-AA as a legitimate alternative, although not a complete replacement, to costly and time-consuming lab-based tests more commonly used to measure SR.

Future intervention studies aimed at stress management for adolescent athletes should consider individual differences in PSR. The PSRS-AA could be used as a screening tool to identify adolescent athletes who are more sensitive to environmental signals and stress, and therefore at greater risk of negative emotionality and decreased life satisfaction. However, PSR can be adapted and changed over-time, with adolescence having been identified as a window of opportunity for stress-based interventions (Romeo, 2010). The PSRS-AA could therefore be used as an outcome measure for interventions with youth athletes, aiming for stable long-term changes in adolescent athletes' reactivity and health.

3.5. Conclusions

Study 1 provides initial support for the use of the PSRS-AA for measuring adolescent athletes' individual differences in PSR (A1). Furthermore, it provides some initial indications of some of the stress and well-being related outcomes associated with adolescent athletes' individual differences in SR (A2). Specifically, PSRS-AA scores were associated with greater neuroticism and introversion as expected, as well as increased perceived stress and reduced subjective well-being, also as expected (O1). This provides initial support for the validity of the PSRS-AA as a self-report measure of adolescent athletes' individual difference in SR.

The PSRS-AA measures an individual difference and construct yet to be examined in any depth with adolescent athletes, and more specifically within sporting contexts for athletes of any age. It has the potential to predict several stress-related outcomes pertinent to the performance and well-being of young athletes during their development. Research and applied practice in the future can use the PSRS-AA to identify stable individual differences in adolescent athletes' total reactivity, without the use of time-consuming, costly, and less ecologically valid lab-based assessments. However, further research is required at this point to examine, within the context of

Lazarus and Folkman’s transactional model, how PSR influences and relates to the stress appraisal and coping process.

Chapter 4. A path analysis of adolescent athletes' perceived stress reactivity, competition appraisals, emotions, coping, and performance satisfaction

In Chapter 3, Study 1 adapted and initially validated the PSRS-AA. The 5-factor structure was confirmed by a CFA, and criterion validity was supported in relation to perceived stress, subjective well-being, and Big 5 personality traits. However, it is still unclear as to how PSR impacts upon performance and wellbeing related outcomes via the stress-coping process. Study 2 therefore aims to further examine the validity of the PSRS-AA, by examining the direct and indirect effects of PSR on adolescent athletes' stress appraisals, emotions, coping, and performance satisfaction (O2). Study 2 also aims to examine the relationships between adolescent athletes' competition appraisals, emotions, coping, and performance satisfaction. This is done via a path analysis, extending a model tested by Nicholls et al. (2012) with adult athletes.

4.1. Introduction

Stress is an ongoing transaction between an individual and their environment (Lazarus & Folkman, 1987). Environmental demands encountered by individuals are commonly referred to as 'stressors' (Fletcher, Hanton, Mellalieu, & Neil, 2012; Lazarus & Folkman, 1987). Cognitive appraisals regarding stressors are made, along with appraisals of the resources available to cope and control the stressor (Fletcher, Hanton, & Mellalieu, 2006; Lazarus & Folkman, 1987). A relational meaning regarding the stressor is then generated by individuals, relating to the perceived challenge or threat posed to the individuals goals or well-being (i.e. what it means to the individual; Lazarus, 1999; Peacock & Wong, 1990). Stressors, depending upon how they are appraised, can then produce negative physical, psychological, and behavioural responses from an individual (collectively referred to as strain; Fletcher et al., 2006), particularly if individuals do not cope with them adaptively (Lazarus & Folkman, 1987).

Competitive sport can produce a large number of stressors which young athletes must cope with (Nicholls et al., 2005; Reeves et al., 2009). These stressors experienced on the day of a competition, for example, can be both performance-related (under-performance or poor form) or of an organisational nature (e.g., playing conditions or relationships with team-mates; Neil, Hanton, Mellalieu, & Fletcher, 2011). In addition, adolescence itself is also associated with numerous stressors (Compas et al., 2001). Adolescents must contend with their burgeoning physical and emotional development, changing social roles and pressures, their growing independence from their parents, as well as academic commitments (Compas et al., 2001; van Rens et al., 2016). This is all while their reactivity to stressors, plus their ability to cope, develops during adolescence (Blakemore & Choudhury, 2006; Nicholls et al., 2009; Romeo, 2010). Furthermore, recent research has suggested that this developmental phase carries on well into an individual's twenties, leading to call for the period of adolescence to be re-defined to 10-25 years of age (Sawyer et al., 2018).

An inability to cope adaptively with the multiple demands of competitive sport can lead to many adverse outcomes, including unpleasant emotions (such as anxiety, guilt, and shame) and performance dissatisfaction (Arnold et al., 2017; Laborde, Dosseville, Wolf, Martin, & You, 2016; Lazarus, 2000; Nicholls et al., 2012). Furthermore, an inability to cope with stressors has been cited as one of the main causes of both burnout and dropout in youth sport (Crane & Temple, 2015; Goodger et al., 2007), and one of the reasons why some talented youth athletes fail to achieve success (Holt & Dunn, 2004). Therefore, assisting young athletes in coping more adaptively with the stressors they experience during this challenging period is important not just for enhancing performance in active individuals, but also maintaining levels of participation and protecting health.

Extensions and adaptations to Lazarus and Folkman's (1987) Transactional model have been made within sporting contexts, particularly in relation to how the stress process influences athletic performance. Fletcher, Hanton, and Mellalieu (2006) outlined how performers, when experiencing emotional responses as a result of primary and secondary appraisal, will also make further tertiary and quaternary appraisals relating to 'emotion-performance fit'. Specifically, athletes will appraise the perceived importance and utility of an emotion to their performance (tertiary appraisal) and their ability to regulate or change the emotion (Fletcher et al., 2006; Neil et al., 2011). Performers with confidence in their ability to regulate their emotional responses, or who appraise emotional responses (positive or negative) as helpful to their performance, will experience 'positive feeling states' (rather than negative feeling states) which facilitate coping and positive outcomes (Fletcher et al., 2006). Some literature has suggested that athletes who appraise negative emotional responses, such as anxiety, as facilitative to performance, can experience positives outcomes (Mellalieu, Hanton, & Fletcher, 2006; Neil et al., 2011). However, there is also evidence to suggest that this association may be explained by the correlation between anxiety and excitement on sport-related emotion scales, with excitement correlating more strongly with subjective measures of performance than anxiety (Nicholls, Polman, Levy, & Hulleman, 2012).

Nicholls et al. (2012) conducted a path analysis of athletes' competition appraisals (the appraisal of an impending competition as a stressor), relational meanings, and emotions prior to competition, and their retrospective self-report coping strategies used during competition, along with their overall performance satisfaction.

Greater appraisals of threat prior to competition were associated with more negative emotions, which were in-turn associated with the greater use of distraction-orientated coping (coping efforts to re-direct attention away from a performance situation; Gaudreau & Blondin, 2002) and disengagement orientated coping (coping efforts designed to physically or emotionally withdraw from a performance situation; Gaudreau & Blondin, 2002) and decreased performance satisfaction. Greater appraisals of challenge were associated with more positive emotions, which were in-turn associated with greater task-orientated coping (coping efforts to manage to performance situation at hand; Gaudreau & Blondin, 2002) and increased performance satisfaction.

The models proposed by Lazarus and Folkman (1987) and Fletcher et al. (2006) identify that stable personal factors (as well as situational factors) can also influence the appraisal and coping process (see Figure 1; Kerdijk et al., 2016). For example, gender (Kaiseler et al., 2012b) the Big Five personality traits (Kaiseler, et al., 2012a), mental toughness, (Kaiseler et al., 2009) and maturity (Nicholls et al., 2015; Nicholls et al., 2013; Nicholls et al., 2009) have all been associated with differences in the way athletes appraise stressors and the coping strategies they employ. The role of individual differences has yet to be examined in relation to the path analysis conducted by Nicholls et al. (2012). Furthermore, this analysis has not been replicated with adolescents. This is significant for a number of reasons given that firstly, adolescent athletes experience a number of unique stressors (Reeves, Nicholls, & McKenna, 2011a), secondly, developmental factors such as physical, emotional, cognitive, and social maturity have a significant effect on how adolescent athletes cope with stressors (Nicholls et al., 2015; Nicholls et al., 2013), and, finally, that reactivity to stressors develops and matures during adolescence (Romeo, 2010).

4.1.1. Stress reactivity

Stress reactivity (SR) has been defined as an individual difference reflecting the broad variability in responses to stressors (Boyce & Ellis, 2005; Ellis et al., 2005; Schlotz, 2013; Schlotz, Hammerfald, et al., 2011; Schlotz, Yim, et al., 2011). SR is thought of as a disposition that is both stable and variable; allowing for situation-specific changes in responses to stressors within a person-specific margin (Schlotz, Hammerfald, et al., 2011; Schlotz, Yim, et al., 2011). Therefore, SR is a personal factor likely to have direct and indirect effects on the stress and coping process (see Figure 1). It is this disposition that is thought to underlie individual differences in associations between stress and disease (Schlotz, Hammerfald, et al., 2011). Despite being a dispositional variable, the development of SR is highly dependent on environmental influences during childhood and adolescence, particularly exposure to both adversity and support (Boyce & Ellis, 2005; Romeo, 2010). A recent meta-analysis has revealed how an increased exposure to adverse childhood experience influences the development of maladaptive reactivity to stress (Hughes et al., 2017).

Adolescence is an important period where SR develops, with this extended period of maturation increasing one's sensitivity to stressors (Ahmed et al., 2015; Romeo, 2010). Hyper-reactivity in adolescents has been associated with internalising symptoms (negative emotionality, anxiety, and depression; Allwood et al., 2011; Granger et al., 1994; Lopez-Duran et al., 2015; Marceau et al., 2012). In adolescent athletes, greater perceived SR has already been associated with a number of outcomes, including greater perceived stress and lesser hedonic well-being (i.e. life satisfaction; Britton, Kavanagh, & Polman, 2017). However, how SR influences these outcomes experienced by adolescent athletes, via the process of appraisal and coping, is currently not known (Britton et al., 2017). It is also not known whether individual differences in

SR influence performance. Furthermore, it is also unknown whether low levels of SR are a potentially protective factor for adolescent athletes.

Given that SR is a dispositional variable that is also adaptable and open to environmental influences such as adversity and social support (Boyce & Ellis, 2005), appropriate interventions could be designed for adolescent athletes with high levels of dispositional SR, to assist them in coping with the multiple demands and stressors associated with being an adolescent athlete, and to potentially develop long-term changes in their reactivity (Britton et al., 2017).

4.1.2. The construct of perceived stress reactivity

SR has been regarded as difficult to measure and assess in athletic contexts (Polman et al., 2010). Adolescents' SR is often measured using physiological (e.g., heart rate variability, cardiac output, blood pressure, skin conductance) and neuroendocrine measures (e.g., cortisol) under the controlled conditions of laboratory protocols (Allwood et al., 2011; Colich et al., 2015; Marceau et al., 2012; McLaughlin et al., 2014; Paysnick & Burt, 2015). However, in dynamic sporting environments, several situational factors may influence stress responses. It is also difficult to delineate between physiological arousal as a consequence of SR and arousal from the physical demands of sport (Polman et al., 2010). Physiological and neuroendocrine measures also have the tendency to be both costly and time-consuming, as well as physically invasive (Schlotz, Yim, et al., 2011).

Britton et al. (2017) therefore adapted Scholtz et al.'s (2011) Perceived Stress Reactivity Scale (PSRS) for use with adolescent athletes, to measure the construct of perceived SR (PSR). PSR has been defined as a disposition that underlies individual differences in physiological and psychological responses to stress (Schlotz, Yim, et al., 2011). The construct of PSR is particularly relevant to Lazarus and Folkman's (1987) transactional model and Nicholls et al.'s (2012) path analysis, given that the psychological stress process is highly dependent on subjective appraisals (See Figure 1). However, it must be noted that the construct of PSR should not be considered a complete replacement for physiological or neuroendocrine measures of SR. This is due to mixed findings in previous research examining the relationship between measures of perceived reactivity and physiological measures (Evans et al., 2013). Stressor appraisals, however, have been found to mediate the relationhsip between PSR and cortisol responses to a controlled laboratory stressor (Schlotz, Hammerfald, et al., 2011). PSR instead provides a more pragmatic, less costly, and less time-consuming alternative to traditional measures of SR, reflecting how individual differences in SR are perceived at a dispositional level by an individual (Schlotz, Yim, et al., 2011).

4.1.3. The present study

The primary aim of this study was to examine the direct and indirect effects of a PSR, measured using the PSRS-AA as a dispositional variable, on the stress, emotion, and coping process among adolescent athletes (O2). This would also aim to further support the validity the PSRS-AA for assessing individual differences in adolescent athletes' PSR, building upon the work of Britton et al. (2017). Given that adolescents are known to appraise and cope with stressors differently to adults (Compas et al., 2001), this study was also interested in examining the relationships between competition appraisals, emotions, coping and performance within a sample of exclusively adolescent athletes, rather than adults, thus building upon Nicholls et al. (2012). The hypothesised model is illustrated in Figure 5, with PSR the main predictor of the model. Arrows indicate a direct effect, plus signs infer a positive relationship, and minus signs a negative relationship.

A number of hypotheses were made regarding the different variables within the model: 1) PSR would have a direct effect on competition appraisal. In addition, it was predicted that PSR would positively predict stressor intensity (primary appraisal), and negatively predict perceived control (secondary appraisal). This was due to previous research associating adolescent athletes' PSR with personality traits associated with greater stressor intensity and perceived lower control (Britton et al., 2017; Kaiseler et al., 2012a). 2) PSR would have both direct and indirect effects (via competition appraisals) on relational meaning. Specifically, PSR would positively predict perceived threat, and negatively predict perceived challenge. This is because PSR has been associated with increased threat appraisals in previous research (Schlotz, Hammerfald, et al., 2011). It was also predicted that participants would make threat appraisals when they appraised themselves as having little perceived control, and challenge appraisals when appraising high perceived control, replicating Nicholls et al.'s (2012) findings. 3) PSR would have both direct and indirect effects (via competition appraisal and relational meaning) on emotion. It was predicted that PSR would positively predict negative emotion, and negatively predict positive emotion. This is because SR has been associated with negative emotionality in adolescents, and PSR has been associated with greater perceived strain overtime in adolescent athletes (Britton et al., 2017; Marceau et al., 2012). It was also predicted that threat appraisals would be associated with greater negative emotions, and challenge appraisals with positive emotions, to replicate the findings of Nicholls et al. (2012).

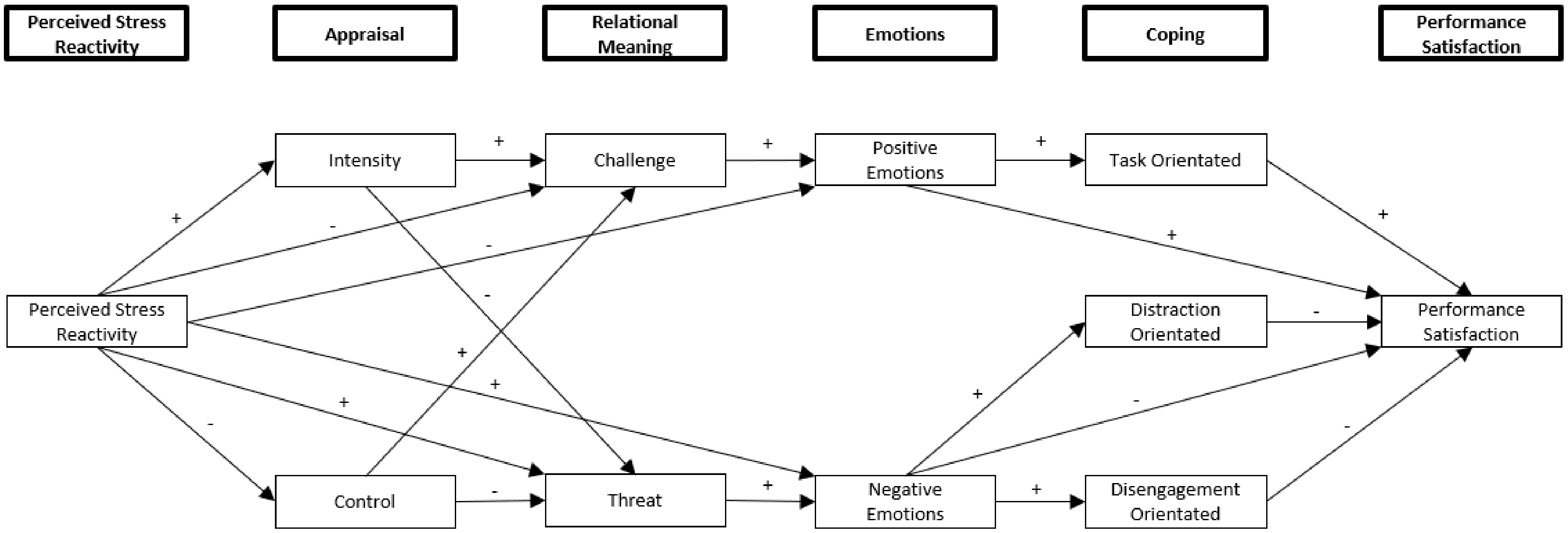

Figure 5: Initial hypothesised model for the relationships between PSR, competition appraisals, relational meanings, emotions, coping, and performance satisfaction

4) PSR would have an indirect effect on coping via competition appraisals, relational meaning, and emotion. PSR would positively affect disengagement and distraction orientated coping, and negatively affect task orientated coping. This was predicted because adolescent athletes' PSR has been related to personality traits associated with coping, namely high levels of PSR with neuroticism, and low levels with emotional stability (Britton et al., 2017; Kaiseler et al., 2012a). It was also predicted that positive emotions would predict task-orientated coping, and negative emotions would predict both distraction and disengagement-orientated coping, as in Nicholls et al.'s (2012) original path analysis. 5) PSR would have a negative indirect effect on subjective performance via competition appraisals, relational meaning, emotion, and coping. Furthermore, it was predicted that emotion would have a direct and indirect effect (via coping) on subjective performance, with positive emotion predicting increased performance satisfaction and negative emotion decreased performance satisfaction. A direct effect of coping on subjective performance satisfaction was predicted, as both are affective variables, and likely to correlate irrespective of coping (Nicholls et al., 2012). Finally, coping would have a direct effect on subjective performance, with task-orientated coping predicting increased performance satisfaction, and both distraction and disengagement-orientated coping predicting decreased performance satisfaction.

4.2. Method

4.2.1. Participants

Participants were 229 adolescent athletes (aged 12-22 years, *M* age = 18.55, *SD* = 2.40; male n = 150; female n = 79;) who competed at international/national (n = 8), regional (n = 11), county/academy (n = 85), club (n = 93), or school/university (n = 32) levels in the United Kingdom. Participants were recruited opportunistically from numerous sports clubs, academies, schools, and universities. They needed to be participating in competitive sport and between the ages of 12 and 22. The sample consisted of 167 adolescents from team sports (including rugby, football, and cricket) and 62 from individual sports (including golf, karate, and badminton). All participants received an information sheet and were asked to sign a consent form prior to the study. For all participants under the age of 16, parents or guardians were also sent an information sheet and asked to provide written consent.

4.2.2. Materials and methods

4.2.2.1. PSR. The PSRS-AA (Britton et al., 2017; Appendix 2) was used to assess individual differences in PSR. The PSRS-AA consists 23 items over five subscales assessing reactivity to different domains: reactivity to social evaluation (‘When I have to perform in front of other people…’), reactivity to social conflict (‘When I have arguments with team-mates and coaches…’), reactivity to failure (‘When I fail at something…’), reactivity to work overload (‘When all my different training sessions and matches build up and become hard to manage…’), and prolonged reactivity (‘When I want to relax after a hard training session or match…’). The aggregate score from these five subscales create an overall score of total reactivity. Each item is assessed using three descriptive multiple-choice options of differing levels of reactivity in response to a proposed stressful situation (e.g. When I have little time to prepare for a match: a. I usually stay calm, b. I usually feel uneasy, c. I usually get quite unsettled). The answers reflecting lowest reactivity are scored zero, while the answers reflecting highest reactivity are scored with two. Intermediate answers are scored one. Subscales scores are calculated via the mean, with each mean subscale score being summed to calculate the aggregate measure of total reactivity. Britton et al. (2017) confirmed the hierarchal structure of the adapted scale using a second order model. The

PSRS-AA's subscales demonstrate only marginal reliability (α = .62 - .73). However, the overall aggregate score of total reactivity is reported as having good reliability (α = .87).

4.2.2.2. Competition appraisals and relational meanings. A version of the 'stress thermometer' was used to assess primary appraisal in the form of perceived stressor intensity prior to competition (Kowalski & Crocker, 2001), with a 10-cm visual analogue scale (VAS) measuring from 0 (not at all stressful) to (extremely stressful) 100 (Appendix 6). The stress thermometer has previously demonstrated normal distribution within a sample of adolescent athletes and has been utilised in many studies measuring athletes' stressor appraisals (Kaiseler et al., 2012a; Kowalski & Crocker, 2001). In order to maintain similarity with the measure of primary appraisal, a 10-cm VAS was also used to measure secondary appraisal in the form of perceived overall control prior to competition (Kaiseler et al., 2012a), measuring from 0 (no control) to 100 (total control; Appendix 6). To maintain further similarity and consistency with the measure of primary and secondary appraisal, levels of both challenge and threat experienced prior to competition were also measured with separate VASs, measuring from 0 (not at all a threat; not at all a challenge) to 100 (very much a threat; very much a challenge). Nicholls et al.'s (2012) original path analysis utilised the 28 item Stress Appraisal Measure (Peacock & Wong, 1990). However, it was decided that a briefer method of assessing appraisals was more suitable for the current study, a) in order not to burden adolescents with copious items prior to competing and thus b) to allow for the completion of the assessments as close to the beginning of competition as possible. The use of VAS are increasingly adopted in order to assess athletes' appraisals of stressors and relational meaning (Kaiseler et al., 2012a; Kaiseler et al., 2012b; Turner, Jones, Sheffield, Barker, & Coffee, 2014; Turner, Jones, Sheffield, & Cross, 2012).

4.2.2.3. Emotions. The Sport Emotion Questionnaire (SEQ; Jones, Lane, & Bray, 2005) was used to retrospectively assess the emotions experienced during competition (Appendix 7). The SEQ assesses five emotions grouped into two higher order dimensions: positive emotions (excitement and happiness) and negative emotions (anxiety, dejection, and anger). The scale contains 22 items scored on a 5-point Likert scale from 0 = ‘not at all’ to 4 = ‘extremely’. The SEQ has been reported to have excellent reliability for its scales, with Cronbach’s alpha ranging from .81 to .90 (Jones et al., 2005).

4.2.2.4. Coping. The Coping Inventory for Competitive Sport (CICS; Gaudreau & Blondin, 2002) was used to retrospectively assess how participants coped during competition (Appendix 8). The CICS measures ten coping subscales grouped into three coping dimensions: task-orientated coping (thought control, mental imagery, relaxation, effort expenditure, logical analysis, and support seeking), distraction-orientated coping (distancing and mental distraction), and disengagement-coping (disengagement and venting). Nine of the subscales feature four items, while one features three items. The scale uses a 5-point Likert scale to assess the extent to which the coping strategy described corresponds with what the athlete did during competition, ranging from 1 = ‘does not correspond at all’ to 5 = ‘corresponds very strongly’. The CICS’s measure of three coping dimensions feature adequate to good levels of reliability (α = .73 to .87) and has been utilised with adolescent athlete populations (Nicholls et al., 2009).

4.2.2.5. Performance satisfaction. Participants subjectively rated how satisfied they were with their performance on a VAS ranging from 0 (‘not at all satisfied’) to 100 ('totally satisfied'; Pensgaard & Duda, 2003; Appendix 9). This subjective measure of performance satisfaction was used instead of an objective measure in order to compare performance across a range of different sports and positions within sports (Males &

Kerr, 1996; Terry, 1995). Furthermore, subjective satisfaction provides a more sensitive measure of performance, that is less likely to be influenced by environmental factors such as playing conditions, weather, or opponents' skill levels (Nicholls et al., 2012).

4.2.3. Procedure

University ethics board approval was obtained prior to data collection. Participants firstly completed the PSRS-AA prior to competition. The VAS measures of competition appraisals and relational meaning were then completed less than one hour before competing at a time and place agreed with by the researcher, participant, and coach if one was present. The SEQ, CICS and VAS measure of performance satisfaction was completed less than one hour after competing also at an agreed time.

4.2.4. Data analysis

The proposed path analysis containing PSR, competition appraisals, relational meanings, emotions, coping, and performance satisfaction was tested in SPSS Amos (v.24) using maximum likelihood estimation. This allows for the simultaneous examination of direct and indirect effect paths throughout the model, while also testing the overall fit of the data to the hypothesised model (Byrne, 2016). For strucutural equation models such as path analyses, 200 cases is considered a minimum requirement as a rule of thumb (Kline, 1998). This requirement was met with the recruitment of 229 participants. The following variables were originally entered: PSR, stressor intensity, perceived control, threat, challenge, negative emotions, positive emotions, task-orientated coping, distraction-orientated coping, disengagement-orientated coping, and performance satisfaction (see Figure 5). The error terms of distraction and disengagement-orientated coping were allowed to co-vary with one another, as they were anticipated to correlate. No other co-variances between shared antecedents were drawn, as no more correlations were predicted based on existing theory. Bivariate correlations were calculated in order to initially analyse the relationships between the variables entered into the model.

A number of indices were used to assess overall model fit. The chi-square statistic assesses the magnitude of discrepancy between the data sample and the co-variance matrix predicted by the model (Hu & Bentler, 1999). However, chi-square is notably sensitive to sample size. Therefore the chi-square/degrees of freedom ratio (CMIN/DF) was used in order to minimise the effect of sample size on determining model fit (Hooper, Coughlan, & Mullen, 2008). A threshold of 3 was used to indicate an acceptable model fit (Kline, 1998). The comparative fit index (CFI) was assessed in order to indicate the extent to which the theoretical model better fitted the data in comparison to a base model where all constructs are constrained to be correlated with one another, with greater than or equal to .95 indicating good model fit, and .90 indicating adequate fit (Hooper et al., 2008; Hu & Bentler, 1999). Root mean square error of approximation (RMSEA) was calculated in order to provide an estimate of the average absolute difference between estimated model covariances and the observed covariances, with less than .06 indicating good model fit (Hooper et al., 2008; Hu & Bentler, 1999). A p value testing the null hypothesis (PCLOSE) of the RMSEA was also assessed, with a non-significant result greater than .05 required to reject the null.

Standardised regression (beta) weights were used to examine the size and significance of the direct effects of PSR specified within the model (Byrne, 2016). To examine the indirect effects of PSR through the model, the probability associated with the standardised indirect effects and their respective confidence intervals (90%) were estimated using a bias-corrected confidence interval bootstrap test (using 500 samples; Byrne, 2016).

4.2.5. Data preparation

Prior to conducting the path analysis, data were screened for outliers and normality. Univariate normality was assessed using skewness and kurtosis values, while multivariate normality was examined using Malhalanobis distances. 7 cases were removed from the analyses due to the presence of multivariate outliers. To test the validity of the questionnaire measures used, confirmatory factor analyses (CFA) using SPSS Amos (v.24) were performed on the SEQ and the CICS. This was to test the fit of the scales and subscales to their proposed higher order structures, so modifications (such as item co-variances or removals) could be made to the scales if required. This would confirm validity of the scale for use with the sample population. The same goodness of fit indices were used. The positive emotion dimension of the SEQ provided good model fit once two co-variances were drawn between the error terms of items 5 and 10, and items 10 and 20 on the happiness subscale (CMIN/DF = 1.73; CFI = .99; RMSEA = .06; PCLOSE = .34). The negative emotion dimension provided good model fit once two co-variances were drawn between the error terms of items 2 and 7 on the dejection subscale and 9 and 19 on the anger subscale, and item 1 was removed from the anxiety subscale due to multiple high modification indices with items on other subscales (CMIN/DF = 1.95; CFI = .98; RMSEA = .06; PCLOSE = .11). The combined model for the whole questionnaire however produced questionable model fit (CMIN/DF = 1.98; CFI = .95; RMSEA = .07; PCLOSE = .01). This may have been due to large covariances between the anxiety subscale and happiness subscale from the positive dimension. However, given that two out of the four fit indices demonstrated adequate model fit (CMIN/DF and CFI) no further modifications were made to the SEQ. Mean scores for the subscales and dimensions of the SEQ were then calculated based upon these modifications.

The task-orientated dimension of the CICS provided adequate model fit after co-variances were drawn between the error terms of items 18 and 28 on the relaxation subscale, and items 9 and 29 on the logical analysis subscale (CMIN/DF = 1.73; CFI = .91; RMSEA = .06; PCLOSE = .12). The distraction subscale provided good model fit once item 3 was removed from the social withdrawal subscale due to large co-variances with items on the mental distraction subscale (CMIN/DF = 1.79; CFI = .96; RMSEA = .06; PCLOSE = .31). The disengagement subscale provided adequate model fit once items 22 and 32 were removed from the venting subscale due to large co-variances with the disengagement subscale (CMIN/DF = 2.99; CFI = .97; RMSEA = .09; PCLOSE = .04). However, no further modifications were made, as CFI indicated good model fit. The three dimensions combined into one model also provided questionable model fit, with no indications that further modifications would improve the model (CMIN/DF = 1.85; CFI = .84; RMSEA = .06; PCLOSE = .00). However, given that the individual dimensions provided good to adequate model fits, analysis proceeded. Mean scores for the subscales and dimensions of the CICS were then calculated based upon these modifications.

4.3. Results

Table 6 provides means, standard deviations, and Cronbach's alpha coefficients for all the variables entered in the model, including discrete emotions and coping strategies. Table 7 provides Pearson's r correlations between all variables entered into the model. Table 8 provides correlations between the discrete coping strategies measured by the CICS and performance satisfaction.

To examine the overall fit of all the data collected, the model shown in Figure 5 was tested. The fit of the model produced inadequate model fit (CMIN/DF = 4.29; CFI

= .79; RMSEA = .12; PCLOSE < .01). Based upon modification indices and correlations within the data set, modifications were made to the model in the form of additional paths. These modifications were only made if they were theoretically sound and did not fundamentally change the nature of the path (Nicholls et al., 2012). An additional path was drawn from control to both negative emotion, and from control to task-orientated coping, as both demonstrated high modification indices, and existing theory would suggest that secondary appraisal of control and coping resources has the potential to directly influence the experience of negative emotions and the use of adaptive coping strategies (Fletcher et al., 2006; Lazarus, 1999; Lazarus & Folkman, 1987).

The overall revised model, however, still produced inadequate fit (CMIN/DF = 3.96; CFI = .82; RMSEA = .12; PCLOSE <.01). Figures 6.1 and 6.2 both illustrate the final model, with separate figures for the ‘positive’ and ‘negative’ paths used for ease of illustration. The significance levels of each path coefficient are included. Table 9 details the direct and indirect effects (plus bias corrected confidence intervals) for PSR and all other variables included in the final model.

Table 6: Mean and standard deviations for variables used in model and Cronbach's alpha coefficients

Scales	Mean	SD	α
Prolonged Reactivity	.42	.36	.48
Reactivity to Work Overload	.45	.38	.57
Reactivity to Social Conflict	.62	.40	.68
Reactivity to Failure	.93	.40	.68
Reactivity to Social Evaluation	.57	.42	.66
Total Reactivity	3.01	1.45	.85
Intensity	42.25	23.63	
Control	61.57	23.52	
Challenge	61.46	20.96	
Threat	35.27	22.70	
Excitement	2.61	.91	.81
Happiness	2.63	1.09	.89
Positive emotions	2.62	.92	.90
Anxiety	1.53	.97	.89
Dejection	1.15	.88	.88
Anger	1.58	.94	.87
Negative emotions	1.42	.77	.90
Thought control	2.95	.87	.68
Mental imagery	2.75	.84	.68
Relaxation	2.33	.98	.84
Effort	3.96	.72	.75
Logical analysis	2.76	.84	.68
Seeking support	2.21	.91	.76
Task-orientated coping	2.83	.61	.89
Social withdrawal	1.79	.70	.55
Mental distraction	1.60	.62	.67
Distraction orientated coping	1.70	.57	.73
Venting	2.47	1.21	.72
Disengagement	1.44	.60	.76
Disengagement orientated coping	1.96	.73	.68
Performance satisfaction	63.90	22.56	

Table 7: Pearson's r correlations between all variables entered into the model

Scales	1	2	3	4	5	6	7	8	9	10
1. Total reactivity										
2. Intensity	.34**									
3. Control	-.23**	-.15*								
4. Challenge	.15*	.52**	-.04							
5. Threat	.29**	.54**	-.07	.47**						
6. Positive emotions	.10	-.02	.10	.02	-.05					
7. Negative emotions	.21**	.24**	-.21**	.27**	.21**	-.04				
8. Task orientated coping	-.04	-.12	.25**	.05	.01	.42**	.06			
9. Distraction orientated coping	.08	.00	.07	.07	.04	.08	.18**	.48**		
10. Disengagement orientated coping	.26**	.14*	.00	.09	.15*	-.02	.40**	.15*	.29**	
11. Performance satisfaction	-.06	.12	.22**	-.07	-.10	.52**	-.36**	.15*	-.16*	-.29**

Note. * $p < .05$., ** $p < .01$

Table 8: Pearson's r correlations between discrete coping strategies and performance satisfaction

Scales	1	2	3	4	5	6	7	8	9	10
1. Thought control										
2. Relaxation	.49**									
3. Effort	.33**	.19**								
4. Logical analysis	.52**	.59**	.33**							
5. Mental imagery	.51**	.50**	.39**	.66**						
6. Seeking support	.25**	.36**	.20**	.39**	.38**					
7. Mental distraction	.26**	.23**	.03	.20**	.30**	.27**				
8. Social withdrawal	.41**	.48**	.07	.43**	.36**	.31**	.49**			
9. Venting	.24**	.01	.01	.19**	.15*	.06	.11	.18**		
10. Disengagement	.07	.10	-.24**	.05	.00	.16*	.31**	.30**	.23**	
11. Performance satisfaction	.07	.02	.32**	.10	.20**	.01	-.10	-.17*	-.17*	-.38**

Note. * $p < .05$., ** $p < .01$

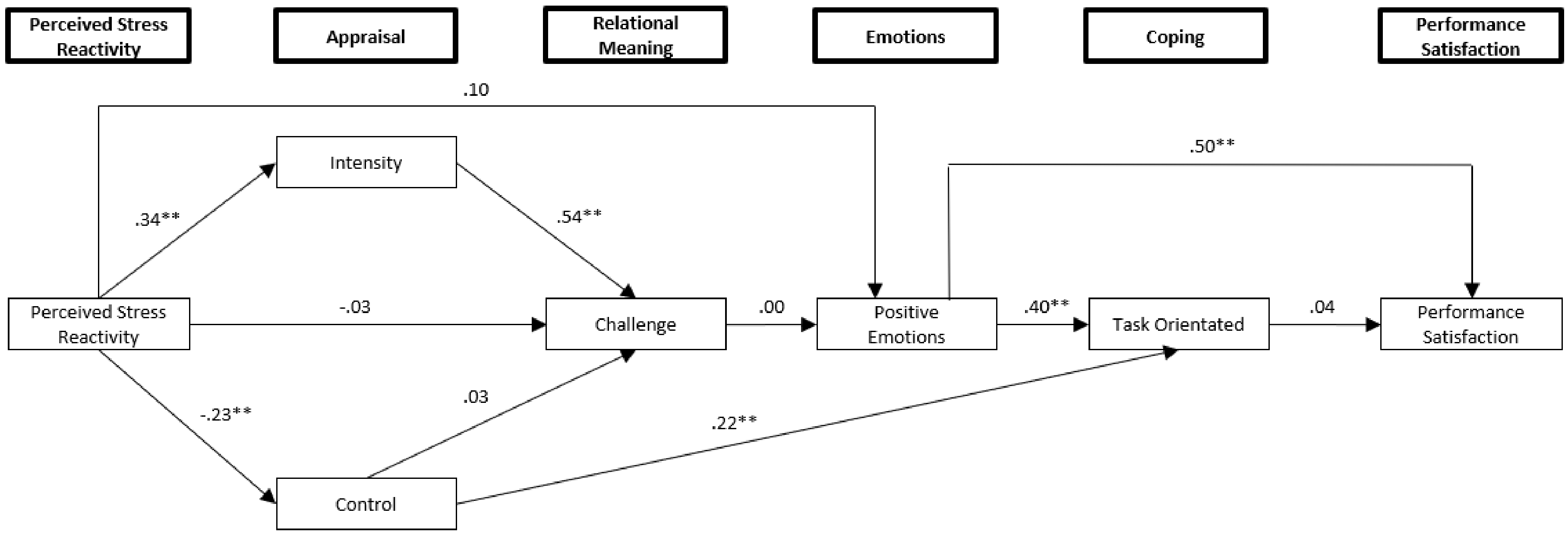

Figure 6.1: Revised model of relationships between PSR, competition appraisals, , challenge, positive emotions, task-orientated coping, and performance satisfaction

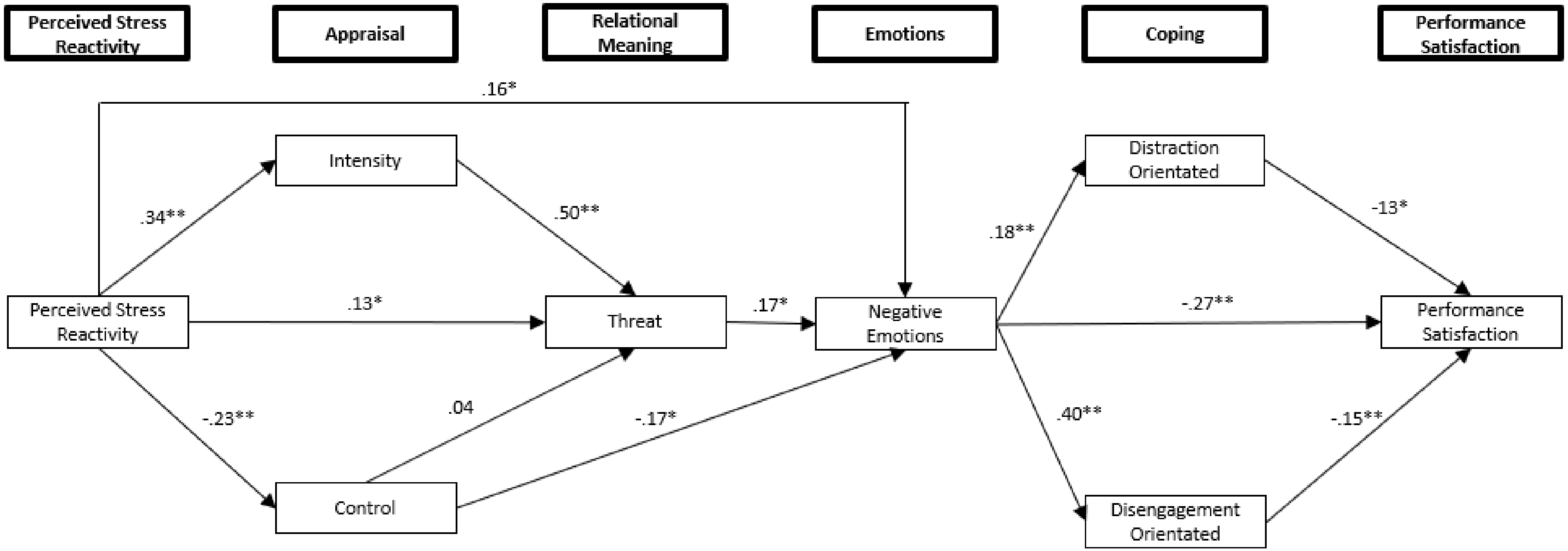

Figure 6.2: Revised model of relationships between PSR, competition appraisals, threat, negative emotions, distraction and disengagement orientated coping, and performance satisfaction

Table 9: Direct and indirect effects of variables entered into the model

Independent Variable	Dependent Variables	Direct	Indirect Sum	Indirect 90% CI
PSR	Intensity	.34**		
	Control	-.23**		
	Challenge	-.03	.18**	.11 .25
	Threat	.13*	.16**	.10, .23
	Positive Emotions	.10	.00	-.02, .02
	Negative Emotions	.16*	.09**	.04, .15
	Task-orientated		-.01	-.07, .05
	Distraction-orientated		.04**	.01, .08
	Disengagement-orientated		.08**	.03, .12
	Performance satisfaction		-.02	-.09, .05
Intensity	Challenge	.54**		
	Threat	.50**		
	Positive Emotions		.00	-.06, .06
	Negative Emotions		.08*	.02, .16
	Task-orientated		.00	-.03, .02
	Distraction-orientated		.01*	.00, .03
	Disengagement-orientated		.03*	.01, .07
	Performance satisfaction		-.03	-.07, .01
Control	Challenge	.03		
	Threat	.04		
	Positive Emotions		.00	-.00, .00
	Negative Emotions	-.17*	.01	-.01, .02
	Task-orientated	.22**	-.00	-.00, .00
	Distraction-orientated		.04*	.01, .08
	Disengagement-orientated		.08*	.03, .12
	Performance satisfaction		-.02*	-.09, .05
Challenge	Positive Emotions	.00		
	Task-orientated		.00	-.04, .05
	Performance satisfaction		.00	-.06, .06
Threat	Negative Emotions	.17*		
	Distraction-orientated		.03*	.01, .06
	Disengagement-orientated		.07*	.02, .12
	Performance satisfaction		-.06*	-.11, -.01
Positive Emotions	Task-orientated	.40**		
	Performance satisfaction	.50**	.02	-.02, .06
Negative Emotions	Distraction-orientated	.18**		
	Disengagement-orientated	.40**		
	Performance satisfaction	-.27**	-.08**	-.14, -.03
Task-orientated	Performance satisfaction	.04		
Distraction-orientated	Performance satisfaction	-.13*		
Disengagement-orientated	Performance satisfaction	-.15**		

Note. * $p < .05$., ** $p < .01$

4.4. Discussion

In this study, path analysis was used to examine adolescent athletes' PSR, competition appraisals and relational meanings prior to competition, emotions and coping strategies during competition, and subjective performance satisfaction. This was in order to explore the direct and indirect effects of PSR on the stress and coping process of adolescent athletes, plus to further extend the path analysis conducted by Nicholls et al. (2012). Although the revised model did not provide an adequate model fit (see Figures 6.1 and 6.2), there were a number of significant direct and indirect effects observed within the model relating to the a-priory predictions (see Table 9) that will be discussed in turn.

PSR demonstrated direct effects on competition appraisals of intensity and control, relational meanings of threat and challenge, and negative emotions. PSR also demonstrated indirect effects on threat, negative emotions, and maladaptive coping (distraction and disengagement-orientated coping). However, PSR failed to demonstrate effects (direct or indirect) on positive emotions, task-orientated coping, or performance satisfaction. Although the analyses shared some similarities with Nicholls et al. (2012), there were also a number of divergences. Overall, these findings provide new information on how PSR influences the stress and coping process, as well as how competition appraisals, emotions, and coping impact upon the performance satisfaction of adolescent athletes. In addition, findings suggest there are some differences in the stress and coping process in adolescents compared to adult athletes.

In relation to the first set of hypotheses, participants with higher levels of PSR were more likely to appraise the impending competition as more stressful, and to appraise themselves as having less control over events, and thus not have the resources to cope. This is consistent with previous research which has found individual differences (most notably neuroticism) to predict athletes appraisals of stressor intensity and perceived control (Kaiseler et al., 2012a). These are among the strongest effects within the model, confirming that an adolescent athletes' perception of how reactive they are to stressors in general has a direct effect on how they cognitively appraise sporting competitions.

With regards to the second set of hypotheses, adolescent athletes with a higher level of PSR were more likely to form a relational meaning of threat in relation to the impending competition. This was partially due to their increased likelihood of scoring the stress relating to the impending competition as more intense. This is consistent with previous research which has associated measures of PSR with increased threat appraisals (Schlotz, Hammerfald, et al., 2011). However, participants with higher levels of PSR were also more likely to appraise the impending competition as a challenge, via the increased appraisal of intensity. This suggests that appraisal is not dichotomous, and that athletic competition can be appraised with a level of challenge and threat at the same time. It might well be that in adolescents this co-existence is more prevalent because of a less developed coping repertoire. This might be supported by the finding that control appraisals did not influence the relational meaning of either threat or challenge. Such a finding does not support theory and previous empirical findings with adult populations that has associated secondary stressor appraisals with relational meanings of challenge and threat (Fletcher et al., 2006; Lazarus & Folkman, 1987; Nicholls et al., 2012). An additional explanation for these findings is the use of only one item each to measure threat and challenge in the present study.

Adolescent athletes who viewed themselves as having greater control prior to competition did experience less negative emotions and used more task-focussed coping strategies. This is consistent with previous empirical findings and theory, suggesting that if adolescent athletes were to perceive themselves as having a high level of control the impending competition, they would have significant resources available to cope and thus would likely experience less negative emotions and have a larger repertoire of task-focussed coping strategies (Amiot, Gaudreau, & Blanchard, 2004; Fletcher et al., 2006; Lazarus & Folkman, 1987; Neil et al., 2011; Nicholls et al., 2012).

In relation to the third set of hypotheses, adolescent athletes with higher levels of PSR were more likely to experience negative emotions during competition. This is explained directly by an adolescent athletes PSR, and also indirectly via cognitive appraisal. This supports previous research that has associated increased reactivity in adolescents with negative emotionality (Marceau et al., 2012). PSR however did not feature any direct or indirect effects on positive emotions. Like appraisal, emotions are also not dichotomous. Adolescent athletes' experience of positive emotions is likely to be determined by other factors which we did not measure in the current study. With regards to appraisals predicting emotions, supporting previous findings, threat was positively associated with negative emotions (Lazarus, 2000; Nicholls et al., 2012). Similarly, decreased control also predicted negative emotions. However, challenge did not predict positive emotions as expected. As indicated previously, the sample characteristics (adolescent athletes) and the way appraisal was measured in the present study might explain this finding. The notion that positive emotions experienced by adolescent athletes are not predicted by any antecedents within the present study supports findings that the stress-coping process in adolescents is different compared to that of adults (Compas et al., 2001; Davis & Compas, 1986).

With regards to the fourth set of hypotheses, adolescent athletes with high levels of PSR were more likely to use coping strategies during competition that are considered maladaptive, via increased threat appraisals and negative emotions. This supports previous research which has observed an association between athletes individual differences and maladaptive coping (Kaiseler et al., 2012a). However, no effects were observed between PSR and task-orientated coping. These findings point towards the notion that the PSR is more likely to predict the maladaptive aspects of high stress reactivity (more negative emotions, maladaptive coping) but that less reactivity is not automatically associated with adaptive outcomes (positive emotions, adaptive coping). Supporting previous findings (Laborde et al., 2016; Nicholls et al., 2012), positive emotions predicted the use of task-orientated coping, and negative emotions predicting both distraction and disengagement-orientated coping.

In relation to the fifth and final set of hypotheses, PSR was found to have no indirect effect on subjective performance satisfaction via the stress and coping process experienced prior to and during competition. This suggests that, in the short-term, high levels of PSR do not have an impact upon the subjective performance of adolescent athletes on the day of competition. However, this is not to say that PSR does not impact upon adolescent athletes' actual and subjective performance and well-being in the long-term. Youth athletes' PSR is associated with increased strain over a 30-day period and decreased life-satisfaction (Britton et al., 2017). Furthermore, athletes experience multiple organizational stressors, other than those in competition, which can impact upon performance (Arnold et al., 2017; Mellalieu, Neil, Hanton, & Fletcher, 2009). Therefore, PSR may influence the appraisal of other organisational stressors experienced by adolescent athletes (such as conflicts with team-mates or training) which may in turn impact upon emotions, coping, and performance in the long-term.

Similar to Nicholls et al. (2012), positive emotions in the adolescent athletes were directly associated with higher and negative emotions with lower levels of subjective performance satisfaction. This association is not unexpected because both are affective variables. At the dimensional level, task-oriented coping was not directly associated with subjective performance whereas more use of distraction and disengagement coping significantly predicted lower levels of subjective performance satisfaction. The correlation matrix, however, showed that the task-oriented coping strategies mental imagery and effort where associated with subjective performance (see Table 8).

Similar to Nicholls et al. (2012) negative emotions indirectly predicted subjective performance satisfaction via distraction and disengagement-oriented coping. However, there was no indirect effect for positive emotions. Overall, the direct and indirect effects on subjective performance satisfaction suggest that adolescent athletes' emotions experienced during competition are greater predictors of performance satisfaction than the coping strategies they use. Specifically, although maladaptive coping strategies predict decreased performance satisfaction, the task-orientated strategies considered effective by adults (Gaudreau & Blondin, 2002; Nicholls et al., 2012) are not associated with increased performance satisfaction among adolescents.

For applied practitioners, these findings have a number of implications. Firstly, practitioners can use the PSRS-AA to identify adolescent athletes most likely to appraise competitions with greater intensity, lesser perceived control, greater perceived threat, more likely to experience negative emotions, and more likely to use maladaptive coping strategies. These athletes can therefore be prioritised for interventions designed to assist them with coping more effectively with the demands of competitive youth sport. Although PSR did not appear to indirectly influence subjective performance in this instance, it is possible that it may influence long-term performance via the multiple organisational stressors athletes experience other than those in competition (Fletcher et al., 2012), as it has already been associated with decreased life satisfaction (Britton et al., 2017).

Having identified adolescents at greatest risk, practitioners could employ a range of interventions to help athletes manage the effects of reactivity on stress and its outcomes. Given that stress is a recursive process (Fletcher et al., 2006; Lazarus, 1999) and that reactivity is a variable disposition (Schlotz, Yim, et al., 2011), successful interventions could bring about long-term adaptations in reactivity over time. Cognitive-behavioural interventions have been found to successfully assist athletes to re-appraise the stressors they experience, reducing perceived threat and elevating perceived challenge, thus having a positive impact upon emotions and performance satisfaction (Didymus & Fletcher, 2017a). Cognitive-behavioural interventions have also been found to be successful in assisting athletes to re-appraise the emotions they experience as being facilitative to their performance (Neil, Hanton, & Mellalieu, 2013). Therefore, even though adolescent athletes with high levels of PSR are more likely to experience negative emotions, they could be encouraged to re-appraise these emotions as helpful to the performance and goals, rather than debilitative. Given the recursive nature of stress (Fletcher et al., 2006; Lazarus, 1999), coping interventions could also prove effective in assisting adolescent athletes with high PSR. Enhancing and refining an adolescent's coping repertoire is likely to affect future appraisals, by increasing coping self-efficacy (Reeves, Nicholls, & McKenna, 2011b). Although previous research has recommended that athletes use a wide range of task-orientated strategies to enhance performance (Gaudreau & Blondin, 2002; Nicholls et al., 2012), correlations within the present data set would suggest that in particular effort expenditure and mental imagery could be taught as coping strategies to adolescent athletes to enhance their performance (see Table 8).

This study has a number of strengths and provides some novel findings. Few studies have examined the associations between competition appraisals, emotions, coping, and performance satisfaction using longitudinal data, let alone with adolescents. The focus on adolescents in this study extends the work Nicholls et al. (2012), with adult athletes. Furthermore, this study also extends existing research by examining the direct and indirect effects of a dispositional factor (PSR) on the stress and coping process. Specifically, the strong associations between PSR and competition appraisals (perceived intensity and control) enhance the validity of the PSRS-AA as a measure of adolescent athletes' individual differences in reactivity, capable of predicting psychological responses to competition stressors.

A general weakness of the study can be found within the reliance on self-report measures, which are associated with numerous biases (Furnham, 1986). Furthermore, there appear to be specific limitations with some of the measure of appraisal and coping utilised within the study. Firstly, the measures of relational meaning (challenge and threat) were significantly positively correlated and were not associated with secondary appraisals of control. The SAM (Peacock & Wong, 1990) used by Nicholls et al. (2012) may have been a more comprehensive measure of appraisal and relational meaning, despite the burden its length may have placed upon participants required to complete it close to the start of competition. Alternatively, given that athletes experience multiple stressors prior to competition other than just the competition itself (Mellalieu et al., 2009), assessing just the appraisals and relational meanings of the competition as a whole may have been too broad for capturing the dynamic nature of stressors experienced.

The measures of task-orientated coping and distraction-orientated coping also correlated. This is a relationship not previously observed between these two variables in both adult or adolescent samples, given that task-orientated strategies are considered adaptive, while distraction-orientated strategies are considered maladaptive (Gaudreau & Blondin, 2002; Nicholls et al., 2009; Nicholls et al., 2012). Given the dynamic nature of sporting competition, athletes, have been known to use coping strategies from across dimensions (Nicholls et al., 2007; Nicholls & Polman, 2007). Only effort and mental imagery from the task-orientated dimension correlated with performance satisfaction. However, coping strategies perceived as effective are not always associated with performance satisfaction (Didymus & Fletcher, 2017b). Therefore, future research may wish to further explore the validity of the CICS for use with adolescent athletes or use alternative measures of coping validated for use with adolescent athletes (Kowalski & Crocker, 2001).

Future research may wish to examine the factors that contribute to the development of SR in adolescent athletes. With a growing understanding of the outcomes associated with PSR in adolescent athletes (Britton et al., 2017), and how it influences the stress and coping process, youth sport organisations may benefit from an understanding of the developmental factors which contribute to some adolescent athletes having higher levels of reactivity than others. Exposure to stressors and support during childhood have already been associated with the development of reactivity in the wider population (Boyce & Ellis, 2005; Hughes et al., 2017). Future research could examine the relationship between adolescent athletes' history of stressors and support experienced within youth support environments and their PSR using the PSRS-AA. Given that PSR appears to be related almost exclusively to negative constructs within the analysis (threat, negative emotion, maladaptive coping), future research may also wish to examine further salutogenic constructs that may explain more positive outcomes (challenge appraisals, positive emotion, task-orientated coping). For example, mental toughness has already been associated with increased appraisals of control, and greater use of effective coping strategies (Kaiseler et al., 2009). Future studies may also wish to examine the relationship between SR and salutogenic constructs such as mental toughness or resilience.

4.5. Conclusions

This study illustrates how adolescent athletes' PSR directly and indirectly relates to competition appraisals, emotions, and coping (O2). This also further builds upon both aims of this thesis. Firstly, the associations with measures of competition appraisals, emotions, and coping further build upon the growing criterion validity of the PSRS-AA initially investigated in Study 1 (A1). Secondly, the study illustrates some of the constrcuts associated with adolescent athletes' individual differences in SR (A2), specifically appraisals of increased stressor intensity, decreased perceived control, increased threat, more negative emotions, and maladaptive coping. This helps to contextualise PSR as a significant personal factor influencing the stress appraisal and coping process of young athletes. However, in the present study, PSR failed to demonstrate an effect on subjective performance via the stress-coping process.

Despite a lack of an effect in relation to subjective performance, these findings do have implications for applied practitioners, as the PSRS-AA could be used to identify young athletes who are at greater risk of experiencing negative emotions and employing maladaptive coping strategies. Practitioners' resources could therefore be more efficiently allocated to adolescents at greatest risk. However, given the nature of the PSRS-AA as a self-report measure, future research at this point is still required to examine the relationship between measures of PSR and physiological processes and responses to stress. This would further enhance the validity of the PSRS-AA as an alternative to physiological measures of SR.

Chapter 5. Perceived stress reactivity in adolescent athletes and students: Associations with re-investment, emotion regulation, stress appraisals, and heart-rate variability

In Chapter 4, Study 2 examined the direct and indirect effects of PSR on adolescent athletes' competition appraisals, emotions, coping, and subjective performance (O2). PSRS-AA scores were found to be directly associated with competition appraisals and emotions, and indirectly with maladaptive coping. However, no indirect effect on performance via the stress-coping process was observed. Chapter 5 features two studies designed to further examine the validity of the PSRS-AA. Study 3.1 aims to further strengthen the validity of the PSRS-AA, by performing a further CFA using a sample of adolescent sportspeople (A1). Furthermore, study 3.1 aims to extend the criterion validity of the scale further, by examing its association with measures of trait re-investment (associated with performance breakdown under pressure) and trait emotion regulation (O1). Study 3.2 aims to validate measures of PSR in relation to physiological processes of stress adaptation and emotion regulation (HF-HRV) in response to a controlled laboratory stressor (O3).

5.1. Introduction

Adolescent athletes experience a significant number of stressors when taking part in competitive sport (Hayward, Knight, & Mellalieu, 2017; Reeves et al., 2011a). These can range from performance related stressors, such as physical and mental errors, as well as organisational stressors, such as conflicts with team-mates and coaches (Arnold et al., 2017). Individuals may also experience multiple demands associated directly with adolescence, such as academic commitments and peer and family relationships (Compas et al., 2001; van Rens et al., 2016). In addition, an adolescent's sensitivity to stress is heightened during adolescence, due to their stage of neurological and physiological development (Ahmed et al., 2015; Romeo, 2010). These developments continue well into an individual's mid-twenties (Blakemore & Choudhury, 2006). Therefore, recent research has recommended expanding the traditional age brackets of adolescence to 10 to 25 years of age in order to reflect this (Sawyer et al., 2018). In other words, an individual is still arguably an 'adolescent' until they are 25 years of age.

An inability to cope adaptively with stress has been associated with increased levels of burn-out and drop-out in youth sport and attributed to talented youth athletes' inability to achieve success later in their careers (Crane & Temple, 2015; Goodger et al., 2007; Holt & Dunn, 2004). Lazarus and Folkman (1987) proposed that stress emerges as an interaction between an individual and their environment, plus the subjective appraisal of potentially stressful events. Therefore, numerous individual differences have been shown to influence how adolescent athletes appraise and cope with stress, including gender (Kaiseler et al., 2012b; Nicholls et al., 2007), the Big Five personality traits (Kaiseler et al., 2012a), and mental toughness (Kaiseler et al., 2009). For example, athletes measuring higher in the trait of neuroticism are more likely to appraise stressors with greater perceived intensity (Kaiseler et al., 2012a). The physical, emotional, and cognitive-social maturity of adolescent athletes have also been shown to influence how they cope with stress (Nicholls et al., 2015; Nicholls et al., 2013; Nicholls et al., 2009). Given the increased sensitivity to stress experienced by adolescents during this period, little research has examined the effects of individual differences in stress reactivity on the performance and well-being of adolescent athletes. Given the vast number of stressors which young athletes encounter during the vulnerable developmental period of adolescence, increasing the risk of burnout and dropout from sport, a better understanding of the mechanisms and effects of stress reactivity among adolescent athletes is important.

5.1.1. Stress reactivity

Personality is ultimately the result of differential reactivity to stimulation from the environment, with introversion and neuroticism being the result of hyper-reactivity (Suls & Martin, 2005). Stress reactivity (SR) has been identified as an individual difference that underlies this broad variability in responses to stress (Boyce & Ellis, 2005; Ellis et al., 2005; Schlotz, 2013). SR develops during adolescence via a period of increased sensitivity (Dumontheil, 2016; Romeo, 2010). However, a recent meta-analysis has also identified that adverse childhood experiences also contribute to the development of increased SR in later life (Hughes et al., 2017). Hyper-reactivity in adolescents has been associated with internalising symptoms during adolescence (negative emotionality, anxiety, and depression; Allwood et al., 2011; Granger et al., 1994; Lopez-Duran et al., 2015). In adolescent athletes, self-reported SR has been associated with reduced satisfaction across multiple life domains, and greater levels of perceived stress over time (Britton et al., 2017). Measuring individual differences in adolescent athletes' SR allows both researchers and practitioners to identify young performers at greatest risk of experiencing negative symptoms and adverse outcomes. Furthermore, the development of reliable measures of SR would facilitate further research regarding how athletes develop during adolescence.

In sporting contexts, it has been considered difficult to reliably measure SR as a stable individual difference (Polman et al., 2010). Adolescent SR is typically measured using physiological or neuroendocrine measures in controlled lab settings (Allwood et al., 2011; Colich et al., 2015; Marceau et al., 2012; McLaughlin et al., 2014; Paysnick & Burt, 2015). However, sporting environments are dynamic by nature, with numerous environmental and situational factors influencing stress responses. It is also difficult to delineate between physiological arousal as a consequence of SR, and physiological arousal in response to the physical demands of sport (Polman et al., 2010). Lab procedures adopted to measure reactivity are also often costly, time-consuming, invasive, and lack ecological validity (Schlotz, Yim, et al., 2011).

5.1.2. Perceived stress reactivity

Britton et al. (2017) developed the Perceived Stress Reactivity Scale for Adolescent Athletes (PSRS-AA). This was adapted from an existing scale (Schlotz, Yim, et al., 2011), in order to specifically assess adolescent athletes' perceived stress reactivity (PSR) across a number of potentially stressful situations. The construct of PSR has been defined as a disposition that underlies individual differences in physiological and psychological responses to stress (Schlotz, Yim, et al., 2011). PSR is particularly pertinent to Lazarus and Folkman's (1987) transactional model of stress, given that physiological and psychological responses to stress are the result subjective appraisals (see Figure 1). However, there have been mixed and equivocal findings with regards to the relationship between measures of perceived reactivity and physiological and neuroendocrine indexes of SR (Evans et al., 2013; Schlotz, Hammerfald, et al., 2011).

The PSRS-AA reflects multiple stress domains (reactivity to social evaluation, reactivity to social conflict, reactivity to failure, reactivity to work overload, and prolonged reactivity) and creates an aggregate score to measure an adolescent athlete's total perceived reactivity. This aggregate score has been found to have good internal consistency, and the overall scale demonstrates acceptable second order model fit (Britton et al., 2017). Support for its criterion validity includes associations with specific personality traits (high neuroticism, high introversion, and low openness), reduced life satisfactions across multiple domains, and higher levels of perceived stress over time (Britton et al., 2017).

Although initial validity for the scale has been provided by Britton et al., (2017), further research is required to build the evidence base surrounding the PSRS-AA. This is in relation to its internal consistency and model fit, its criterion validity in relation to other traits and individual differences associated with athletic performance, and its validity in relation to physiological stress responses. Therefore, the following studies aimed to achieve this, in part, by examining the criterion validity of the PSRS-AA in relation to several other measures and related constructs.

5.1.3. Re-investment

Re-investment is a dimension of personality implicated in skill breakdown under pressure, associated with movement self-consciousness (MSC) and conscious motor processing (CMP; Masters, Eves, & Maxwell, 2005; Masters & Maxwell, 2008). Trait re-investment, and the self-focussed behaviours associated with it, have been found to detrimental to athletic performance (Kinrade, Jackson, & Ashford, 2010; Malhotra, Poolton, Wilson, Uiga, & Masters, 2015; Maxwell, Masters, & Poolton, 2006; Mosley et al., 2017). This is due to self-focussed attention regressing high level skill execution to a state more akin to the earlier stages of skill development, thus disrupting execution. Re-investment can be caused by a number of contingencies, including, most notably, psychological pressure and negative affect (Masters & Maxwell, 2008). Given that a predisposition to greater SR in adolescence is associated with greater levels of negative affectivity (Allwood et al., 2011; Marceau et al., 2012), one would expect that measures of PSR would relate to measures of trait re-investment. This would be via greater levels of negative affectivity, leading to modifications in attention and conscious motor control. This would enhance the criterion validity of the PSRS-AA.

5.1.4. Emotion regulation

The processes of both stress-coping and emotion regulation share many similarities and differences (Wang & Saudino, 2011). Stress-coping involves consciously changing efforts to manage internal or external demands. Emotion regulation, on the other hand, can involve both implicit and explicit modulation of internal emotional changes to meet demands (Gross & Jazaieri, 2014). Furthermore, emotion regulation does not always occur in response to a specific situation or event and involves the control and modulation of both positive and negative emotions (Wang & Saudino, 2011). Despite these differences, stress-coping and emotion regulation share many of the same neural networks. Specifically, they are both associated with activation of the pre-frontal cortex (PFC), and modulation of the amygdala. Furthermore, both processes are associated with activation of the hypothalamic-pituitary-adrenal axis (HPA). Emotion regulation predicts elevations in cortisol in response to stress, and both processes involve the modulation of both affect and appraisals of events or states (Wang & Saudino, 2011). Of importance to this study, the shared neural networks and structures associated with both stress-coping and emotion regulation develop during adolescence and into young adulthood (Ahmed et al., 2015; Blakemore & Choudhury, 2006). Therefore, one would propose that measures of adolescent athletes' PSR are likely to be related to measures of emotion regulation.

There are numerous methods for assessing emotion regulation. However, few have been used within sporting contexts with athletes. A popular self-report measure used within the wider population is the Emotion Regulation Questionnaire (ERQ; Gross & John, 2003), which assesses emotion regulation at a trait level, measuring tendencies to use two types of emotion regulation: Cognitive reappraisal and emotional suppression. The ERQ has received some, if limited, support within sporting contexts, with cognitive re-appraisal being associated with the experience of pleasant emotions (Uphill, Lane, & Jones, 2012). In the general population, emotional suppression is associated with unpleasant emotions, and is thus considered maladaptive (Gross & John, 2003). Furthermore, trait emotional suppression has been found to predict higher cortisol levels in response to stressors (Lam, Dickerson, Zoccola, & Zaldivar, 2009). However, Uphill et al. (2012) noted that in athletic samples, the use of cognitive re-appraisal and emotional suppression appear to be strongly correlated. A relationship between scores on the ERQ and the PSRS-AA would support that the process of both stress and emotion regulation are related and would therefore add to the criterion validity of the PSRS-AA.

5.1.5. Heart rate variability

Physiologically, high-frequency heart rate variability (HF-HRV; .15-.40 Hz) can be used as an index of emotion regulation (Thayer et al., 2012). The Neurovisceral Integration model proposes an adaptive system of neural structures that regulate cognition, perception, action, and physiology in the face of physiological and environmental demands. This includes a bi-directional connection between the heart and the brain via the vagus nerve. Tonic and phasic increases in HF-HRV index activation of the parasympathetic nervous system, and thus the PFC. This in turn increases the PFC’s inhibitory control over the amygdala; regulating emotions. Predispositions to high levels of SR are likely to dysregulate this integrative system, with greater sympathetic activation, decreased activation of the PFC, followed by disinhibition of the amygdala, indexed by low levels of HF-HRV (Thayer et al., 2012).

Gender differences have been observed in HF-HRV, with men having higher levels of HRV compared to women (Woo & Kim, 2015), while greater levels aerobic fitness has been shown to influence faster recoveries in HRV after exercise (Stanley et al., 2013). Furthermore, recent research has identified associations between HF-HRV and performance related variables under pressure conditions (Laborde et al., 2015; Mosley et al., 2017). Therefore, one would expect that, controlling for gender and athleticism, PSRS-AA scores would be associated with tonic and phasic measurement of HF-HRV in response to a novel stressor featuring physical and/or socially evaluative threat. This would also support that the processes of stress and emotion regulation are related. Furthermore, it would further support the use of the PSRS-AA as a valid alternative lab-based methods of indexing individual differences in SR.

5.2. Study 3.1

5.2.1. Aims and hypotheses

The first aim of study 3.1 was to examine the psychometric properties of the PSRS-AA (Britton et al., 2017) in terms of its factorial structure and reliability (A1). The second aim was to further examine the criterion validity of the PSRS-AA by exploring its association with the trait reinvestment and trait emotional regulation (O1). Regarding the first aim, an appropriate 5 factor model fit using CFA was hypothesised. With regard to the second aim it was hypothesised that higher levels of PSR would be associated with lower levels of trait emotional regulation (less cognitive reappraisal and more emotional suppression), and higher levels of trait reinvestment (both MSC and CMP).

5.2.2. Materials and methods

5.2.2.1. Participants. Participants were 216 adolescent athletes (aged 12-22 years, *M* age = 18.72, *SD* = 2.47, male *N* = 147, female *N* = 69) competing at international/national (*N* = 12), regional (*N* = 24), county/academy (*N* = 67), club (*N* = 83), and school/university (*N* = 30) levels. Participants were recruited opportunistically from numerous sports clubs, academies, schools, and universities. Participants were required to be participating in competitive sport at any level. The sample consisted of 52 adolescents from individual sports, and 164 from team sports. All participants received an information sheet and were asked to sign a consent form prior to the study. For all participants under the age of 16, parents or guardians were also sent an information sheet and asked to provide written consent.

5.2.2.2. Measures. The PSRS-AA (Britton et al., 2017) features 23 items and consists of five subscales assessing reactivity to different domains: reactivity to social evaluation ('When I have to perform in front of other people…'), reactivity to social conflict ('When I have arguments with team-mates and coaches…'), reactivity to failure ('When I fail at something…'), reactivity to work overload ('When all my different training sessions and matches build up and become hard to manage…'), and prolonged reactivity ('When I want to relax after a hard training session or match…') (Appendix 2). The aggregate score of total reactivity is created from the sum of these five subscales. Each item uses three descriptive multiple-choice options of differing levels of reactivity in response to a proposed stressful situation (e.g. When I have little time to prepare for a match: a. I usually stay calm, b. I usually feel uneasy, c. I usually get quite unsettled). The PSRS-AA's subscales have demonstrated questionable to adequate reliability (α = .62-.73; Britton et al., 2017). However, the overall aggregate score of total reactivity has shown good reliability (α = .87).

The ERQ (Gross & John, 2003) was used to assess trait levels of emotion regulation (Appendix 11). 6 Items of the ERQ assess the tendency to use cognitive reappraisal (e.g., 'when I want to feel more positive emotion, I change what I'm thinking about'), and 4 items assess the tendency to use emotional suppression (e.g., 'I control my emotions by not expressing them'). Both subscales had good internal consistency: emotional suppression (α = .73), cognitive reappraisal (α = .79).

The Movement Specific Re-investment Scale (MSRS; Masters et al., 2005) was used to assess traits levels of CMP and MSC (Appendix 10), which have been associated with skill-breakdown under pressure in athletes. The MSRS is a 10-item scale, with 5 items each measuring CMP (e.g., 'I try to think about my movements when I carry them out') and MSC (e.g., I am concerned about what people think about me when I am moving) scored on a 6-point likert scale ranging from 'strongly disagree' to 'strongly agree'. The scales in the present study had good internal consistency: CMP (α = .71), MSC (α = .78).

5.2.2.3. Analysis. CFA based on maximum likelihood estimation and a co-variance matrix was conducted using SPSS AMOS (v. 23). A minimum of 200 cases is often considered a rule of thumb minimum for CFA (Kline, 1998), and this was achieved with the recruitment of 216 participants. A correlated traits model was used to test the PSRS-AA's five factor structure (Bryne, 2016). Lambda was set to 1 for each first observed indictor of the latent variables and the error weights, with all other parameters being freely estimated. The goodness-of-fit indices used to determine model fit were as follows: (1) Chi squared/degrees of freedom (CMIN/DF; less than 3 indicating an acceptable fit; Kline, 1998), (2) comparative fit index (CFI; greater than or equal to .95 indicating a good fit and .90 indicating an adequate fit; Hu & Bentler, 1999) and root mean square error of approximation (RMSEA; less than .06 indicating a good fit; Hu & Bentler. 1999), plus the *p* value testing the null RMSEA (PCLOSE; a non-significant result greater than .05 to reject the null), were all assessed to measure the model's fit (Hu & Bentler, 1999). Model modification was carried out using modification indices, factor loadings, and drawing of co-variances between correlated errors supported by a strong rationale, such as clear item content overlap, and the replication of error co-variances from previous research (Byrne, 2016). CFAs were also performed on the MSRS and the ERQ to test their model fit, before testing the PSRS-AA's criterion validity.

Cronbach's alpha scores were calculated to test the PSRS-AA's internal consistency within its subscales and its total reactivity scores (.60 to .69 being questionable, .70 to.79 being acceptable, and .80 and above being good; Kline, 1999). Criterion validity of the PSRS-AA was tested using Pearson's *r* correlations with the MSRS subscales of CMP and MSC, and the ERQ subscales of emotional suppression and cognitive reappraisal (correlations from .10 to .29 being classified as small, .30 to .49 medium, and .50 and above large; Cohen, 1992).

5.2.3. Results

5.2.3.1. Internal consistencies. Cronbach's alpha scores indicated good internal consistency for the measure of total reactivity, while scores for the individual subscales ranged from acceptable to questionable (see Table 10).

5.2.3.2. Confirmatory factor analysis. Initial analysis using a five-factor correlated traits model produced an unacceptable level of fit for the PSRS-AA (CMIN/DF = 1.58; CFI = .89; RMSEA = .05; PCLOSE = .72). The modification indices provided by AMOS indicated that items 13 and 15 on the reactivity to failure subscale were highly correlated. The content of these two items shared clear content overlap (item 13: *When I do not achieve a goal: a) I usually remain annoyed for a long time, b) I am usually disappointed, but recover soon, c) In general, I am hardly concerned at all*; item 15: *When I fail at something: a) I usually find it hard to accept, b) I usually accept it to some degree, c) In general, I hardly think about it*).

Table 10: Means, Standard Deviations (SD) Internal Consistency (Cronbach's α) scores.

Scales	Mean	SD	α
Prolonged Reactivity	.40	.36	.51
Reactivity to Work Overload	.45	.40	.62
Reactivity to Social Conflict	.65	.42	.68
Reactivity to Social Evaluation	.57	.42	.66
Reactivity to Failure	.94	.41	.68
Total Reactivity	3.02	1.49	.86
Cognitive reappraisal	4.67	.95	.78
Emotional suppression	3.84	1.29	.74
Movement self-consciousness	18.73	6.37	.82
Conscious motor processing	22.76	4.93	.72

Therefore, co-variances were drawn between these two items. The resulting analysis provided an acceptable fit to the five-factor structure (CMIN/DF = 1.47; CFI = .91; RMSEA = .04; PCLOSE = .90; see Figure 5).

For the MSRS, initial analyses produced an unacceptable model fit based on its RMSEA score (CMIN/DF = 1.97; CFI = .95; RMSEA = .07; PCLOSE = .12). Therefore, co-variances were drawn between the error terms of items 7 and 9 on the CMP subscale as they demonstrated high modification indices. The resulting analyses provided good model fit (CMIN/DF = 1.77; CFI = 96; RMSEA = .06; PCLOSE = .25).

The ERQ also initially produced unacceptable model fit (CMIN/DF = 2.19; CFI = .93; RMSEA = .07; PCLOSE = .04). Two co-variances were then drawn between the error terms of items 1 and 2, and items 1 and 3 on the cognitive reappraisal subscale, as they demonstrated high modification indices. The resulting analyses provided good model fit (CMIN/DF = 1.72; CFI = 96; RMSEA = .06; PCLOSE = .29). No further modifications were made to the MSRS or the ERQ. Since no items were removed of either the MSRS or ERQ the original scoring was used.

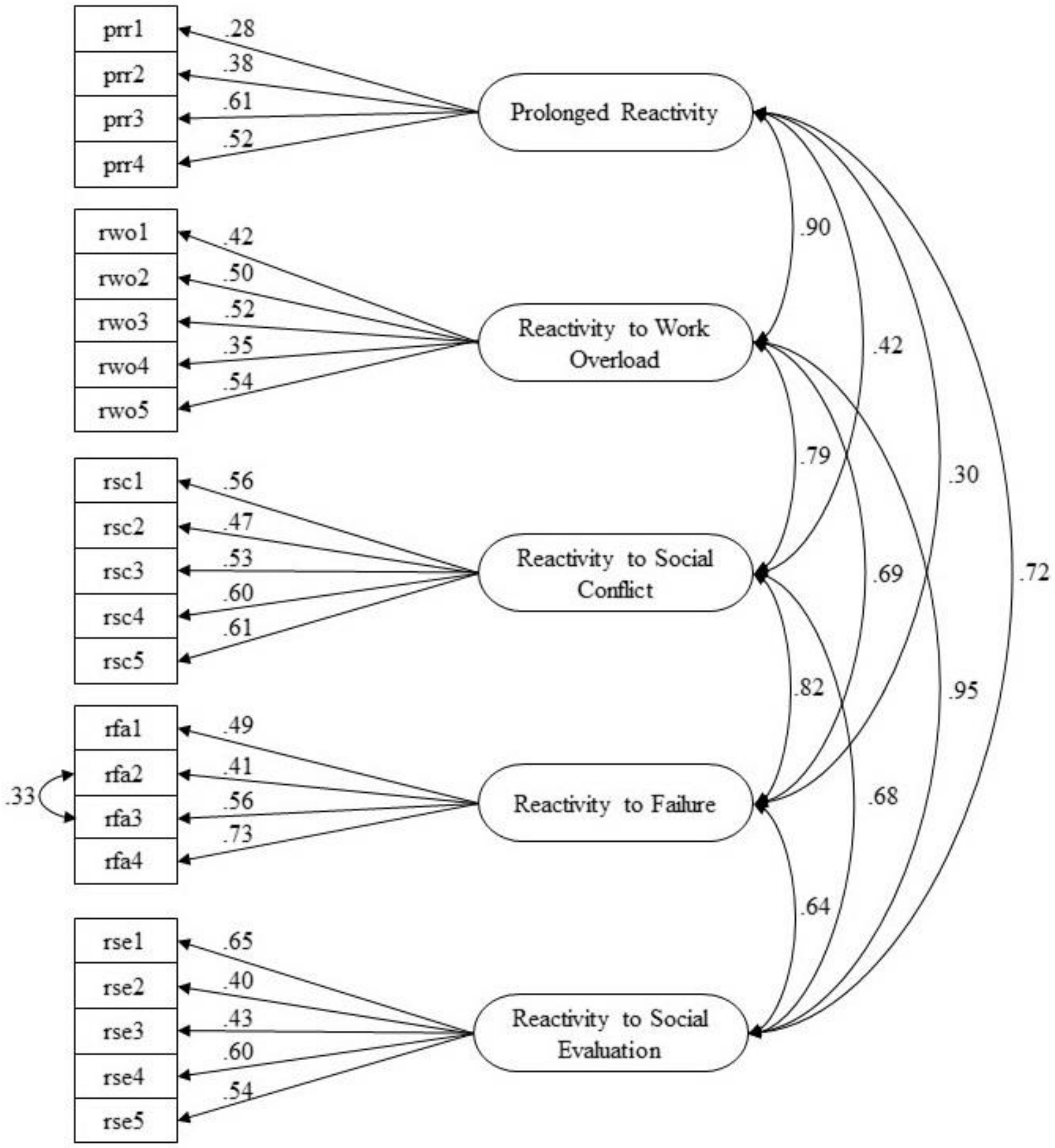

Figure 7: Confirmatory factor analysis of the PSRS-AA using a correlated traits model.

Table 11: Pearson's R correlations between MRS, ERQ, and PSRS-AA subscales.

Scales	Prolonged Reactivity	Reactivity to Work Overload	Reactivity to Social Conflict	Reactivity to Social Evaluation	Reactivity to Failure	Total Reactivity
Cognitive reappraisal	.04	-.04	-.14*	.02	-.07	-.06
Emotional suppression	-.01	.05	-.19**	.17*	-.10	-.02
MSC	.22**	.21**	.16*	.20**	.02	.20**
CMP	.10	.14*	.03	.01	.08	.01

Note. * $p < .05$. ** $p < .01$

5.2.3.3. Criterion validity. Table 11 provides an overview of the correlations between the PSRS-AA (total score and subscale scores) and the reinvestment and emotion regulation factors. Total reactivity was only associated with the MSC factor. Similarly, four of the five PSRS-AA factors also showed small positive correlations with MSC. There was only one small association between CMP and reactivity to work overload. For emotional regulation, there was only a small negative correlation between cognitive reappraisal and the reactivity to social conflict subscale of the PSRS-AA. Finally, emotional suppression was positively correlated with reactivity to social evaluation but negatively to reactivity to social conflict.

5.2.4. Discussion

In this study, a CFA was conducted to further test and validate the structure of the PSRS-AA. The analysis confirmed the scale's five factor structure using a correlated traits model with adequate model fit. There was good internal consistency for the scale's aggregate score of total reactivity, however less so for the individual subscales. Secondly, the criterion validity of the PSRS-AA was examined via a correlation matrix containing measures of trait re-investment and emotion regulation. A number of small yet signiciant relationships were observed. MSC was positively associated with total reactivity and all but one of the PSRS-AA's subscales. Only reactivity to work overload was associated with CMP. Cognitive reappraisal was only negatively associated with reactivity to social conflict, while emotional suppression was positively associated with reactivity to social evaluation but negatively associated with reactivity to social conflict.

The CFA replicates the findings of Britton et al. (2017) and supports the PSRS-AA's five factor structure. This further supports the need for measuring PSR across multiple domains (for example, reactivity to failure, reactivity to social evaluation), as there appears to specificity in reactivity to different types of stimuli. These differences should therefore be considered before making a generalisation about an adolescent athlete's 'total reactivity'. However, analysis using the individual subscales should be approached with caution due to the internal constituency of the individual subscales. The PSRS-AA's aggregate score of total reactivity is more reliable.

As predicted, MSC was positively associated with total reactivity, indicating that adolescent athletes with high levels of PSR are more likely to be self-conscious of their movements, and therefore may be more likely to experience movement failure under pressure. Associations with the PSRS-AA's subscales indicate that adolescent athletes who are more reactive to social evaluation, social conflict, work overload, and prolonged stress are more likely to be self-conscious of their movements and motor skills. Only reactivity to work overload was found to have an association with CMP. This suggests that adolescent athletes who are more reactive to increased workloads are more likely to consciously process their motor skills. Overall, this partially supports previous research in the field of re-investment in sporting contexts, which has proposed stress to be a related trigger for reinvestment (Masters & Maxwell, 2008).

For the measures of trait emotion regulation, only reactivity to social conflict was found to have an association with cognitive reappraisal. This suggests that adolescent athletes who are more reactive to social conflicts (with parents, coaches, team-mates, and match officials for example), are less likely to regulate their emotions by changing the content of their thinking. Emotional suppression was found to have two opposing relationships with two PSRS-AA's subscales. An association was observed between reactivity to social evaluation and emotional suppression. This suggests that adolescent athletes who are more reactive to social evaluation (being observed, criticised, or judged by others) are more likely to avoid expressing their emotions. However, an unexpected negative relationship was found between reactivity to social conflict and emotional suppression. Based on this finding, adolescent athletes who are more reactive to social conflicts are potentially less likely to supress their emotions. Taken alongside the results from the cognitive reappraisal measure, this suggests that young athletes who are more reactive to social conflicts are less likely to regulate their emotions, neither supressing them nor engaging in cognitive reappraisal. This is likely due to adolescents not having the repertoire of coping and regulatory strategies of adults (Compas et al., 2001). This also partially supports findings from Uphill et al. (2012), which found that, rather than being opposing constructs, trait cognitive appraisal and trait emotional suppression are in fact correlated in athletic populations. Given these inconclusive results using the ERQ in this study, further research is needed to examine the relationship between PSR and emotion regulation using alternative measures.

5.3. Study 3.2

5.3.1. Aims and hypotheses

The aim of study 3.2 was to examine the validity of the reactivity to social evaluation (RSE) subscale of the PSRS-AA in relation to a physiological measure of emotion regulation: HF-HRV (O3). The study also examined the validity of a socially evaluated cold pressor test (SECPT; Schwabe et al., 2008) for use with adolescent athletes, and to examine gender and athleticism differences in response to the SECPT in student athletes and non-athletes. This was due to previous research which has found HF-HRV differences between genders and levels of athletic fitness (Stanley et al., 2013; Woo & Kim, 2015). This study aimed to examine whether these differences could be observed using the SECPT.

It was hypothesised that: controlling for gender and athleticism, the RSE subscale would relate to tonic and phasic changes in HF-HRV before, during, and after the SECPT. Specifically, higher levels of self-reported RSE would be associated with lower HF-HRV before, during, and after the task, and would be related to greater decreases in HF-HRV from before the task to during (reactivity), and smaller increases in HF-HRV after the task (recovery); finally, also controlling for gender and athleticism, the RSE subscale would also be associated with greater ratings of perceived stress, pain, and unpleasantness immediately after the task.

In order to confirm the validity of the SECPT, a number of additional hypotheses were made: There would be significant changes in HF-HRV from before to during the task, with reactivity being indexed by a reduction in HF-HRV, recovery by an increase; lower levels of HF-HRV reactivity during the task would be associated with subjective appraisals of greater stress, pain, and unpleasantness immediately after the task; greater levels of tonic and phasic HF-HRV would be observed in males;

greater levels of tonic and phasic HF-HRV would be observed in student athletes compared to student non-athletes.

5.3.2. Materials and methods

5.3.2.1. Participants. Sixty-one students were recruited to the study (*M* Age = 20.11, *SD* = 1.25, Male *N* = 28, Female *N* = 33). Thirty of the students participated in competitive sport, while thirty-one did not. All participants were in full-time education at a UK university. The study was approved by a university ethics committee and all participants provided written consent prior to testing.

5.3.2.2. Measures. The RSE subscales of the PSRS-AA (for student athletes) and the original PSRS (for student non-athletes) was used for this study (Appendix 1; Appendix 2). This was due to the conditions of social evaluation threat the SECPT is designed to produce. Although previous studies have demonstrated questionable reliability of the PSRS-AAs RSE subscale ($\alpha = .66$; Britton et al., 2017), data collected from this study produced good reliability for the subscale ($\alpha = .78$).

HRV was measured using the eMotion Faros 180° device (Mega Electronics Ltd., Pioneerinkatu, Finland). Two pre-lubricated disposable electrodes (Ambu VLC-00-S/25, Ambu GmbH, Bad Nauheim, Germany) were placed below the left clavicle and the left side below the 12th rib. Immediately after completing the SECPT, participants rated their perceptions of how stressful, painful, and unpleasant the task was, on three visual analogue scales (VAS) of 10 centimetres in length, from 0 (‘not at all’) to 10 (‘very much’) (Appendix 12).

5.3.2.3. Procedure (SECPT). Prior to testing, participants completed the PSRS-AA or PSRS electronically, and were invited via email to take part in the SECPT. Participants were asked to refrain from eating, consuming caffeine, smoking within two hours testing, and consuming alcohol within 24 hours of testing, due to their impact on cardiac variables (Laborde et al., 2017). Participants also had to avoid any intensive physical activity within 24 hours of testing and to have adhered to their regular sleeping pattern. Participants were asked if they had any cardiac disease, respiratory disorder, or blood pressure problems, or were taking any medication that may affect the heart and thus the results of the study. Using a pre-testing checklist, none of the above were reported prior to testing.

On arrival, participants were informed that they would be video-taped while they performed the task. This was to achieve the social evaluative element of the SECPT. Participants then provided written informed consent before checking they had adhered to the pre-testing requirements (Appendix 13). Participants were then fitted with the Faros 180° device, seated in a chair, and asked to remain as still as possible while resting HF-HRV was measured for three minutes. This was to achieve a baseline measure of HF-HRV at rest. The video camera positioned directly in front of them three metres away was then turned on. After the completion of the baseline measure, participants were instructed to submerge their right hand, up to and including their wrist, into an insulated box of cold ice water (0°C - 4°C) positioned on a platform directly next to them, while remaining as still as possible (to not disrupt the measurement of HF-HRV) and maintaining eye contact with the camera lens. They were encouraged to keep their hand in the water for up to a maximum of three minutes, however they were informed that they had the right to remove their hand from the water at any time if they felt that they could no longer keep it submerged, and that this would not affect the results. During the SECPT the primary researcher sat in an observer's position directly next to the camera, facing the participant. Upon completion of the task (either after 3 minutes or on voluntary termination), the camera was switched off, and participants were asked to complete the VAS scales of stressfulness, pain, and unpleasantness. Participants were then asked to remain still and seated for a further 3 minutes to assess HF-HRV during a recovery post-task. The Faros 180° device was then removed, and the data saved, while participants were debriefed (Appendix 13).

5.3.2.4. Data preparation. HF-HRV data from two participants was unable to be analysed due to equipment failure. Furthermore, two participants' post-task data was unable to be analysed. Finally, one participant withdrew from the study before completing the task, having had their HF-HRV measured at rest. The HF-HRV data was processed for artefacts before indicators of reactivity (the phasic change between rest and task levels) and recovery (the phasic change between task and post-task levels) were calculated. Absolute power statistic was used, which is deemed a reliable measure of HF-HRV and parasympathetic activation (Laborde et al., 2017). A log10 transform was applied on the HF-HRV data as it was not normally distributed. This is common practice with data obtained from the absolute power statistic (Laborde et al., 2017). Once this was performed, the data was visually checked and deemed to be normally distributed.

5.3.2.5. Data analysis. An a priori analysis was initially performed to calculate the required sample size using Gpower v3.1. A medium effect size (f^2=.15), α error probability of >.05, and power (1-β error probability) of .8 were input as parameters, resulting in a minimum required sample size of *N*=55. This minimum requirement was met with the recruitment of 61 participants. To assess the effectiveness of the SECPT in inducing stress responses in the sample, a set of analyses were performed. Firstly, paired samples t-tests were performed between the tonic measurements of HF-HRV measured before and during the task, and during and after the task. This was to establish if there were significant differences between the tonic measures of HF-HRV at different stages of the SECPT. Secondly, Pearson's r correlations were calculated between the measures of HF-HRV (tonic measure during the task, and phasic measure of reactivity from rest to task) and the VAS scales of stressfulness, pain, and unpleasantness. This was to establish whether tonic and phasic measures of HF-HRV were correspondingly related to the participant's subjective appraisals of stress during the task.

To further examine potential differences in HF-HRV in relation to gender and athleticism, a two-way MANOVA was performed. Independent factors were gender and whether the participants were involved in competitive sport (athleticism), while all five measures of tonic and phasic HF-HRV were examined as dependent variables. Given the unequal group sizes for both gender and athleticism, Pillai's trace was used to assess within-subjects effects.

To explore the validity of the reactivity to social evaluation subscale, multiple regression analyses using the enter method were performed. Gender and athleticism were controlled for at step one, before entering the RSE subscale at step two. B, beta, R^2, and $\triangle R^2$ were all included in the output. Analyses were performed for all five measures of tonic and phasic HF-HRV, and for the three VAS measures of self-reported stress, pain, and unpleasantness.

5.3.3 Results

5.3.3.1 SECPT validity. Table 12 shows means and standard deviations for the HF-HRV and VAS measures. Paired samples t-tests revealed no significant differences between HF-HRV from rest to task: $t(57) = .85$, $p = .40$. Furthermore, there were no significant differences between HF-HRV from task to post-task: $t(55) = -1.17$, $p = .25$. Table 13 details Pearson's r correlations HF-HRV variables (during task and reactivity) and VAS measures of subjective stressfulness, pain, and unpleasantness. Moderate significant negative correlations were observed between HF-HRV during the task and both perceived stressfulness and perceived pain, but not unpleasantness. No significant correlations were observed between HF-HRV reactivity and any of the subjective VAS measures.

5.3.3.2. Gender and athleticism differences in HF-HRV. Estimated marginal means are detailed in Table 14. Multivariate tests revealed no significant effect of gender or athleticism on HF-HRV (see Table 15). Analysis of each independent variable revealed male participants to have significantly higher levels of resting HF-HRV than female participants (see Table 16). No other significant differences were found between the dependent and independent variables.

Table 12: Means and standard deviations for HF-HRV and VAS variables.

Scale	Mean	SD
HF-HRV rest	3.03	.42
HF-HRV task	2.98	.52
HF-HRV post-task	3.08	.45
HF-HRV reactivity	-.05	.44
HF-HRV recovery	.08	.49
VAS stress	3.86	2.54
VAS pain	6.36	2.53
VAS unpleasantness	6.58	2.46

Table 13: Pearson's r correlations between HF-HRV task and reactivity variables, and VAS scales.

Variable	Unpleasantness	Stress	Pain
HF-HRV task	-.25	-.32*	-.35**
HF-HRV reactivity	-.03	-24	-.13

Note. * $p < .05$. ** $p < .01$.

Table 14: Estimated Marginal Means for Gender and Athleticism.

HF-HRV Variable	Group Variable	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Rest	Male	3.19	.09	3.01	3.36
	Female	2.90	.08	2.74	3.07
	Athlete	3.02	.08	2.86	3.18
	Non-athlete	3.07	.09	2.89	3.25
Task	Male	3.14	.11	2.93	3.35
	Female	2.86	.10	2.66	3.06
	Athlete	3.04	.10	2.85	3.24
	Non-athlete	2.96	.11	2.74	3.17
Post-task	Male	3.17	.10	2.98	3.36
	Female	2.98	.09	2.80	3.16
	Athlete	3.04	.09	2.86	3.21
	Non-athlete	3.12	.10	2.92	3.31
Reactivity	Male	-.05	.09	-.24	.13
	Female	-.04	.09	-.22	.13
	Athlete	.02	.09	-.15	.19
	Non-athlete	-.12	.09	-.30	.07
Recovery	Male	.03	.10	-.17	.24
	Female	.12	.10	-.07	.32
	Athlete	-.01	.10	-.20	.19
	Non-athlete	.16	.11	-.05	.37

Table 15: Multivariate tests for gender and athleticism on HF-HRV.

Variables	Pillai's Trace	F	*df*	Error *df*	*p*	Partial η^2
Gender	.13	2.37	3	50	.08	.13
Athleticism	.03	.46	3	50	.71	.03

Table 16: Between subjects effects.

Group variable	HF-HRV variable	F	*df*	Error *df*	*p*	Partial η^2
Gender	Rest	5.69	1	52	.02	.10
	Task	3.64	1	52	.06	.07
	Post-task	2.02	1	52	.16	.04
	Reactivity	.01	1	52	.94	.01
	Recovery	.40	1	52	.53	.01
Athleticism	Rest	.19	1	52	.66	.00
	Task	.35	1	52	.56	.01
	Post-task	.40	1	52	.53	.01
	Reactivity	1.18	1	52	.28	.02
	Recovery	1.39	1	52	.24	.03

5.3.3.3. Validity of reactivity to social evaluation subscale. Table 17 details the results of the multiple regression analysis. Controlling for gender and athleticism at step one, no significant associations were found between RSE and any of the HF-HRV variables. There were significant associations between reactivity to social evaluation and the subjective VAS measures. RSE was significantly correlated with VAS scores for perceived stressfulness and pain, but not unpleasantness.

Table 17: Multiple regression analyses for RSE whilst controlling for gender and athleticism at step 1.

Steps and variables		B	Beta	R^2	$\triangle R^2$
Dependent variable: HF-HRV rest					
Step 1	Gender	-.30	-.36*	.12*	
	Athleticism	.03	.04		
Step 2	RSE	.00	.00		.00
Dependent variable: HF-HRV task					
Step 1	Gender	-.30	-.29	.12*	
	Athleticism	-.11	-.11		
Step 2	RSE	-.02	-.02		.00
Dependent variable: HF-HRV post task					
Step 1	Gender	-.19	-.21	.04	
	Athleticism	.09	.13		
Step 2	RSE	.00	.00		.00
Dependent variable: HF-HRV reactivity					
Step 1	Gender	.00	.00	.03	
	Athleticism	-.15	-.17		
Step 2	RSE	-.03	-.03		.00
Dependent variable: HF-HRV recovery					
Step 1	Gender	.09	.09	.05	
	Athleticism	.17	.17		
Step 2	RSE	.01	.01		.00
Dependent variable: VAS unpleasant					
Step 1	Gender	1.36	.28*	.14*	
	Athleticism	.78	.16		
Step 2	RSE	1.02	.22		.04
Dependent variable: VAS stressfulness					
Step 1	Gender	1.70	.34*	.11*	
	Athleticism	-.06	-.01		
Step 2	RSE	1.42	.30*		.08*
Dependent variable: VAS pain					
Step 1	Gender	2.21	.44**	.18**	
	Athleticism	-.13	-.03		
Step 2	RSE	1.45	.30*		.08*

Note. * $p < .05$. ** $p < .01$.

5.3.4. Discussion

In this study, the validity of the PSRS-AA's RSE subscale was tested in relation to a physiological index of emotion regulation and subjective measures of perceived stress, recorded during a SECPT in student athletes and non-athletes. The validity of the SECPT for inducing stress responses and changes in HF-HRV in student athletes and non-athletes was also tested, along with the effects of gender and athleticism on HF-HRV in the sample population. No significant differences in HF-HRV were observed between the rest and task periods, or the task and post-task periods . However, there were significant relationships between HF-HRV during the SECPT and the subjective VAS measures, with lower levels of HF-HRV being associated with greater perceptions of stress and pain. There was no effect of athleticism on HF-HRV. There was also no overall effect of gender on HF-HRV. However, there was a significant effect on baseline HF-HRV, with males having higher levels than females. The RSE subscale failed to relate to HF-HRV. However, the subscale was significantly associated with the subjective VAS measures of both stress and pain taken immediately after the SECPT.

These results suggest that the SECPT was not effective in producing changes in HF-HRV. However, with lower levels of HF-HRV being associated with greater perceptions of stress and pain, this indicates that the task itself was indeed stressful and painful for participants, and that these perceptions of stress and pain were related to levels of HF-HRV during the SECPT. The SECPT may have failed to produce significant changes in HF-HRV across the three testing periods, due to the demands of the baseline resting and post-task periods. Participants were instructed to remain as still as possible during these periods, which may have been demanding enough to provoke changes in HF-HRV, rather than produce a reliable baseline. Therefore, further research is required to test the validity of the SECPT for measuring changes in HF-HRV in athletic and non-athletic populations.

These results also suggest that there are no differences in HF-HRV between student athletes and non-athletes. This did not support the hypothesis or previous research which has found aerobic fitness to predict higher levels of HF-HRV (Stanley et al., 2013). However, this may be due to the measure of athleticism used in the study (whether participants competed in sporting activities). This did not control for non-athletes with potentially high levels of aerobic fitness. Although there was also no overall main effect of gender on HF-HRV, there was a significant effect on baseline HF-HRV, with males having higher levels than females. This supports the findings of previous research into gender differences in HRV (Woo & Kim, 2015). Therefore, future research into HF-HRV and SR should continue to control for gender differences, particularly when conducting baseline assessments.

With the RSE subscale failing to relate to HF-HRV, this would suggest that the construct of PSR does not directly relate to the physiological processes of stress and emotion regulation. This is despite its relationships with numerous personality traits and psychological outcomes demonstrated in studies 1, 2, and 3.1. However, with RSE relating to the subjective VAS measures of both stress and pain taken immediately after the SECPT, this suggests that PSR relates more strongly to perceptions of stress rather than physiological processes. This is consistent with Lazarus and Folkman's transactional model of stress, which proposes that stress emerges from an interaction between an individual and their environment, plus the subjective appraisal of potentially stressful events. Furthermore, this also supports findings from study 2, which found PSR of adolescent athletes to directly affect appraisals of stress prior to competition.

5.4. General discussion

This study aimed to further validate the PSRS-AA as a measure of adolescent athletes' PSR, by examining its internal and criterion validity. This would provide a self-report measure of PSR specifically for adolescent sporting contexts, reflecting reactivity to a range of stressful situations an adolescent athlete may encounter. Adequate model fit for the PSRS-AA was confirmed, and relationships with trait reinvestment and trait emotion regulation also added to the criterion validity of the PSRS-AA. The RSE subscale was associated with perceptions of stress and pain experienced during the SECPT as expected. This supports previous finidngs from studies 1 and 2 that found the PSRS-AA to be associated with perceived stress and stress appraisals . However, the PSRS-AA was not associated with HF-HRV in response to a controlled laboratory stressor, suggesting that PSR bears more of a relationship with psychological responses to stress (i.e. appraisals) than physiological responses.

These findings have several implications for future research. Firstly, the relationship between PSR and re-investment could be further examined, by investigating the predictive validity of the PSRS-AA in relation to skill breakdown under pressure. This would confirm whether PSR is a contingency for skill breakdown under pressure, or merely related construct to trait re-investment. From the results of both studies, the relationship between PSR and emotion regulation also requires further investigation. Despite sharing many of the same neural structures and networks (Wang & Saudino, 2011), PSR was only very partially related to trait emotion regulation (measured using the ERQ). With trait emotional suppression being both positively and negatively associated with different subscales of the PSRS-AA, this suggests that the relationship between PSR and trait emotion regulation is complex, particularly in relation to reactivity to different domains. Future research could aim to clarify these relationships further, by using alternative measures of trait emotion regulation (see Zelkowitz & Cole, 2016).

With PSRS-AA scores not being associated with HF-HRV, but perceived stress in response to the SECPT, future research may wish to avoid using the PSRS-AA as a replacement for physiological measures of SR. Instead, the PSRS-AA may be used as an alternative or complementary measure, which more closely aligns with cognitive theories and processes of stress (i.e. Lazarus & Folkman, 1987), rather than physiological processes. However, future research may wish to test the validity of the PSRS-AA further in relation to other physiological or neuroendocrine markers of SR. HF-HRV is a marker of para-sympathetic activation, therefore future research could conduct the SECPT with measures of sympathetic reactivity (e.g. salivary alpha amylase or skin conductance response). Furthermore, different lab procedures could also be used to provoke stress responses, given that there were no significant differences in HF-HRV between the different phases of the SECPT (e.g. The Trier Social Stress Test; Kirschbaum et al., 1993). Independent from the findings related to the PSRS-AA, male participants were found to have higher levels of HF-HRV at rest than females. Future research should therefore continue to control for gender differences when examining HF-HRV, in both student athletes and non-athletes.

In terms of future applied practice, these findings also have some implications. Results from the SECPT would suggest that adolescent athletes scoring high on the PSRS-AA should be prioritised for interventions which address the cognitive appraisal of stress under conditions of social evaluation. Given the lack of a relationship between the PSRS-AA and HF-HRV, interventions designed to directly address physiological processes (i.e. relaxation techniques) may not be effective for young athletes scoring highly on the scale. However, results from the ERQ would suggest that young athletes who are highly reactive to social conflicts (with their team-mates or coaches for example) would benefit from being taught strategies to regulate their emotions, either through cognitive reappraisal of such stressors, or the modulation of their emotional responses. Furthermore, the ERQ also suggests that reactivity to social evaluation is associated with higher levels of trait emotional suppression. Trait emotional suppression is associated with unpleasant emotions and is considered a maladaptive form of emotion regulation (Gross & John, 2003). Therefore, adolescent athletes measuring high in RSE may benefit from being taught alternative strategies to emotional suppression, such as cognitive reappraisal, to regulate their emotions more adaptively when faced with stressors associated with social evaluation. However, future applied practice would benefit from further research into individual differences and trait emotion regulation in adolescent athletes given these limited findings using the ERQ. Overall, given that adolescent athletes regularly face stressors associated with social evaluation, the PSRS-AA can be utilised to identify, and thus support, young athletes at greatest risk of experiencing decreased satisfaction with their sporting experience and thus dropout.

In relation to re-investment, the PSRS-AA can also be used to help identify adolescent athletes who are more likely to engage in movement self-conscious as a result of their reactivity to stressors. Given that increased movement self-consciousness is associated with skill breakdown under pressure, adolescent athletes scoring highly on the PSRS-AA would be more likely to experience sub-optimal performance when under pressure. It is therefore recommended that adolescent athletes scoring highly on the PSRS-AA be provided interventions that address increased movement self-consciousness and thus reduce the likelihood of skill breakdown under pressure (see Gröpel & Mesagno, 2017 for review).

5.5. Conclusions

These two studies enhance and refine the validity of the PSRS-AA for assessing individual differences in adolescent athletes' PSR (A1). It demonstrates that the scale provides adequate model fit, suggesting that PSR can be assessed across different stress domains. In study 3.1, PSRS-AA's criterion validity was supported further, through its relationship with trait re-investment, and thus implicates PSR in skill breakdown under pressure (O1). The scale also demonstrates partial criterion validity in relation to a self-report measure of trait emotion regulation, however further research may be required with alternative measures to investigate this relationship (O1). However, in study 3.2, little support was obtained regarding the relationship between PSR and outcomes associated with stress and well-being (A2). Specifically, the PSRS-AA's relationship with the physiological processes of stress and emotion regulation was not confirmed (O3). Finally, perceptions of stress and pain in response to a novel stressor are associated with greater PSR, enhancing the PSRS-AA's criterion validity. Future research should examine the relationship between SR and emotion regulation further and consider individual differences in PSR when exploring stress appraisals and subjective processes within stress-coping and emotion regulation. Overall, this further supports PSR as a significant individual difference affecting the experience of stress in adolescent athletes that is worthy of further research.

Chapter 6. General Discussion

6.1. Introduction

This thesis aimed to develop and validate a measure of adolescent athletes' SR (A1), and to investigate the outcomes associated with adolescent athletes' individual differences in SR (A2). The three main objectives of the thesis were to support the criterion validity of a measure of SR (O1), to examine the role of SR in the stress appraisal, emotion, coping, and performance of adolescent athletes (O2), and to examine the association between SR and a physiological measure of emotion regulation in student athletes and non-athletes (O3).

In chapter 2, a systematic literature review was conducted to identify the long-term outcomes associated with SR in adolescence, plus the methods used to assess it. In chapter 3, a self-report measure of adolescent athletes' perceived SR was developed (the PSRS-AA), through the adaptation of the PSRS, and an initial analysis was performed to support its structure, validity, and reliability. This included the scale's relationship with the Big 5 personality traits, perceived stress over time, and life satisfaction. In chapter 4, a path analysis was performed to examine the direct and indirect effects of PSR on adolescent athletes' competition appraisals, emotions, coping strategies, and subjective performance satisfaction. Chapter 5 featured two further studies. Firstly, the criterion validity of the PSRS-AA was examined in relation to several traits pertinent to the performance and well-being of adolescent athletes. Finally, the predictive validity of the scale was examined in relation to a physiological measure of stress and emotion regulation (HF-HRV) in response to a SECPT. This was carried out with a sample of student athletes and non-athletes completing the PSRS-AA and the original PSRS respectively.

The following discussion is in four parts. Firstly, the findings presented in the previous chapters are summarised in relation to each of the objectives and predictions made in 1.3.2 and 1.3.3 respectively. Secondly, the theoretical implications of the findings are discussed in relation to the two main aims: 1) the development of the PSRS-AA; 2) the outcomes associated with adolescent athletes' PSR. Thirdly, the implications for future applied practice are outlined. Finally, the limitations of the research are discussed, along with directions for future research.

6.2. Summary of findings

The systematic review in chapter 2 identified measures of individual difference in adolescents' SR, plus the long-term outcomes associated with individual differences in SR during adolescence in the general population. This was in order to inform the selection of a measure of SR to adapt and validate for future studies (A1).

High levels of SR during adolescence were associated with internalising symptoms (such as negative emotionality, depression, anxiety, and social withdrawal) both during adolescence and in later life. In the studies reviewed, the majority utilised physiological (e.g., HR, skin conductance) or neuroendocrine (e.g., cortisol) measures of SR using lab-based procedures (such as social stress tests and cognitive tasks). However, many of these physiological and neuroendocrine methods lacked the ecological validity to reflect the multiple types of stressors (i.e. stress domains) experienced by adolescent athletes in real-world sporting contexts. Given these limitations, it was decided to adapt a self-report measure of perceived SR (PSR), reflecting a disposition underlying individual differences in responses to stress (Schlotz, Hammerfald, et al., 2011). This measure would allow for the assessment of reactivity to multiple stress domains using a single-time-point self-report of typical stress responses in sporting contexts.

In chapter 3, the PSRS (Schlotz, Yim, et al., 2011) was adapted for adolescent athletes, with 23 items measuring perceived reactivity to social conflict, social evaluation, failure, work overload, and prolonged reactivity, and the sum total of these subscales creating an aggregate score of total reactivity. Having been completed by 243 adolescent athletes, a CFA using a second order model confirmed its 5-factor structure contributing to an aggregated score of total reactivity. Further analyses were also performed to test specific predictions (O1). PSRS-AA scores were positively associated with perceived stress experienced over a 30-day period prior to testing as hypothesised. The PSRS-AA was negatively associated with both emotional stability and extraversion on the measure of Big 5 personality traits as hypothesised. An unexpected negative association with openness was also found on the Big 5. As hypothesised, the measure was also negatively associated with overall life satisfaction. Finally, females scored higher on the PSRS-AA compared to males as hypothesised.

Chapter 4 examined the direct and indirect effects of PSR on competition appraisals, emotion, coping, and performance satisfaction (O2). Although the analysis produced inadequate overall model fit, a number of significant effects were observed. PSR demonstrated direct a positive effect on the appraisal of stressor intensity and a direct negative effect on perceived control. Direct positive effects were also observed with the relational meaning of threat and the experience of negative emotions. Indirect positive effects were also observed on relational meanings of challenge (mediated by stressor intensity) and distraction and disengagement-orientated coping. However, hypotheses that total reactivity would predict positive emotions, task-orientated coping, and performance satisfaction were not supported.

Chapter 5 examined a) a further CFA and analysis of the PSRS-AA and its criterion validity (O1); and b) the predictive validity of the scale in relation to HF-HRV responses to a SECPT in student athletes and non-athletes (O3). CFA using a correlated traits model further supported the PSRS-AA's 5-factor structure. A correlation matrix using measures of trait emotion regulation and trait movement re-investment showed that reactivity to social conflict was negatively associated with trait cognitive reappraisal, while trait emotional suppression was positively associated with reactivity to social evaluation and negatively associated with reactivity to social conflict, only partially supporting predictions. Total reactivity was positively associated with trait MSC as expected; however, trait CMP was only positively associated with reactivity to work overload. Controlling for gender and athleticism, the PSRS-AA failed to predict any of the tonic or phasic measures of HF-HRV during the SECPT procedure. However, the scale was positively associated with measures of perceived stressfulness and perceived pain taken immediately after the task, but not perceived unpleasantness.

Correlations, t-tests, and a two-way MANOVA were performed to validate the use of the SECPT for inducing stress and HF-HRV responses with the sample of student athletes and non-athletes. No significant differences were observed between HF-HRV measured pre-task, during the task, or post-task . There were significant negative correlations between tonic HF-HRV measured during the task and the measures of perceived stressfulness and pain, but not unpleasantness. No significant associations were observed between the subjective measures and the phasic measure of HF-HRV reactivity. There was no overall main effect of gender on HF-HRV, but at rest males did display higher levels of HF-HRV than females. No effects of athleticism on HF-HRV were observed.

6.3. Theoretical implications

6.3.1 Development of the PSRS-AA

SR had yet to be examined as an individual difference within adolescent athlete populations, despite its potential implications for performance, well-being, and development (Boyce & Ellis, 2005; Ellis et al., 2005). The systematic review of the literature revealed a lack of ecological validity in the measures used to assess individual differences in adolescent SR. Specifically, the literature was dominated by measures of SR which used controlled lab procedures, rather than reactions to real-world stressors. Single responses to stressors in controlled laboratory settings were often generalised to reflect reactivity to all stressful stimuli. This is problematic, given that this thesis aimed to examine individual differences in SR specifically within the context of sport. Furthermore, Schlotz (2013) has stated: “It is not possible to use the stress response in one domain or system as a general indicator of responses in another domain” (p. 1892). There were also practical limitations to the use of physiological and neuroendocrine measures, given that they are often costly, time-consuming, invasive, and difficult to interpret and analyse (Schlotz, Hammerfald, et al., 2011). Therefore, it was decided to adapt a self-report measure of PSR, a disposition underlying individual differences in responses to stress, that would use a single-time-point self-report assessment of an individual’s typical stress responses to different stimuli (The PSRS; Schlotz, Yim, et al., 2011).

The CFAs in studies 1 and 3.1 provided evidence for the sound factorial structure of the PSRS-AA, replicating the 5-factor structure of the original scale and supporting the concept of measuring PSR across different domains (Schlotz, Yim, et al., 2011). The criterion validity of the PSRS-AA was supported by large correlations with neuroticism and perceived stress, a medium correlation with life satisfaction, and small correlations with introversion, openness, trait re-investment, and trait emotion regulation. The path analysis partially supported the predictive validity of the scale, with total reactivity scores having direct effects on competition appraisals, relational meanings, negative emotions, and indirect effects on maladaptive coping. Appraisals of stress and pain assessed immediately after the SECPT were also associated with RSE subscale scores. However, no effects were observed between total reactivity scores and positive emotions, task-orientated coping, or subjective performance. Furthermore, no associations with HF-HRV during the SECPT were found.

Overall, the PSRS-AA appears to be a valid measure of PSR for adolescent athletes. The scale is closely associated with the traits of neuroticism and introversion, supporting the notion that personality is built upon reactivity to environmental stimuli (Suls & Martin, 2005). The PSRS-AA relates to the cognitive processes adolescent athletes experience, such as appraisals and emotions. However, study 3.2 failed to observe a relationship with physiological responses to stressors (HF-HRV). This could have been due to a number of reasons, including the validity of the PSRS-AA itself, or the effectiveness of the SECPT in producing an appropriate stress response. Therefore, considering our current level of knowledge, the PSRS-AA should not be used as a replacement for physiological measures of SR. Rather, the PSRS-AA could be used as an alternative to physiological measures, capable of predicting several psychological and cognitive responses to stressors experienced by adolescent athletes. In other words, the construct of PSR may not be entirely reflective of individual differences in SR at a physiological level, but best described as a related psychological trait underlying these individual differences (Schlotz, Yim, et al., 2011).

A potential weakness of the PSRS-AA is the positive skew of scores it produces. The positive skew of PSRS-AA scores may explain why no effects were observed for total reactivity scores on positive emotions and adaptive coping. However, the aim of the questionnaire is to reflect perceived reactivity to stress, and not positive adaptations (i.e. coping). Adapting the scale further to reflect this would risk significant overlap with a measure of coping rather than PSR, given that coping is a voluntary process (Compas et al., 2001) and PSR is a disposition underlying involuntary reactions to stress (Schlotz, 2013). Therefore, the PSRS-AA appears to relate more strongly to negative appraisals, negative emotions, and maladaptive coping, and is thus a dispositional measure relating to these constructs. With that considered, the PSRS-AA should be utilised to identify young athletes at greatest risk of experiencing increased stress intensity, threat, and negative emotions when exposed to stressors, and thus several negative outcomes. However, low scores should not be conversely used to identify adolescent athletes most likely to cope adaptively with stressors, given that low PSR scores do not appear to predict positive emotions or adaptive coping.

6.3.2. Outcomes associated with adolescent athletes' PSR

6.3.2.1. PSR and well-being. Findings from study 1 indicate that adolescent athletes' PSR is associated with well-being. Specifically, it is associated with greater levels of perceived stress and lower levels of life satisfaction. This was observed across multiple life domains, as well as overall life satisfaction. This implicates heightened levels of PSR as a significant risk not just to adolescent athletes' wellbeing within sporting contexts, but across multiple life domains. With increased stress and dissatisfaction being associated with burn-out and dropout from youth sport (Crane & Temple, 2015; Goodger et al., 2007), this would suggest that adolescent athletes with high levels of PSR could be more likely to cease their sporting activities if exposed to significant stressors.

6.3.2.2. PSR, appraisal, emotion, and coping. Findings from study 2 reveal that PSR has a significant direct effect on adolescent athletes' appraisal of both stressor intensity and control prior to competition. This is also supported by findings in study 3.2, with PSR significantly associated with greater levels of perceived stress and pain measured immediately after the SECPT. PSR also demonstrated direct and indirect effects on appraisals of threat prior to competition, and the experience of negative emotions and use of maladaptive coping strategies during competition. This builds upon previous research which has examined the effect of individual differences on athletes' appraisals and coping (Kaiseler et al., 2009a; Kaiseler et al., 2012a), as well as studies that have used path analyses to examine these processes within athletes (Nicholls et al., 2012). Overall, these associations demonstrate how individual differences in PSR relate to the stress and coping process in adolescent athletes. Reactive individuals are more likely to appraise stressful situations with greater perceived intensity, with less perceived control, and thus view them as being a greater threat to themselves, experience more negative emotions, and then use maladaptive strategies in an attempt to cope. Given the vast number of stressors adolescent athletes encounter, this can put them at a greater risk of experiencing more stress and negative emotions over time as they participate in competitive sport.

6.3.2.3. PSR and performance. PSR failed to demonstrate an effect on adolescent athletes' ratings of subjective performance after competition via the stress and coping process in study 2. Although no effects on subjective performance ratings were observed on a single competitive performance, this is not to say that PSR may impact upon adolescent athletes' (subjective and/or objective) performance in the long-term. Athletes experience multiple stressors other than those directly associated with competition (Mellalieu et al., 2009; Reeves et al., 2011a). PSR may influence performance satisfaction, as well as satisfaction with one's sporting experience in general, via the appraisal of a multitude of stressors over time. On the other hand, the failure to observe an effect on subjective performance via stress and coping process in study 2 may be explained by psychometric weaknesses in the measures of appraisal and coping used (see 6.6.2.).

Results from study 3.1, however, do reveal implications for PSR and adolescent athletes' performance. PSR demonstrated a significant association with trait reinvestment, specifically movement self-consciousness. Given that pressure and negative affectivity have been identified as contingencies for reinvestment (Masters & Maxwell, 2008), it would appear that a predisposition to greater stress reactions is associated with a tendency to be self-conscious of one's own movements, which in turn is allied with the breakdown of athlete's motor skills when under pressure (Masters et al., 2005; Maxwell et al., 2006). The use of subjective self-report measures of performance and re-investment in these studies warrant the need for further research using objective measures of performance in the future.

6.3.2.4. PSR and emotion regulation. The relationship between adolescent athletes' PSR and emotion regulation at both a trait and state level remain unclear. In study 3.1, reactivity to social evaluation and social conflict were associated with increased and decreased trait emotional suppression respectively, while only reactivity to social conflict was associated with lesser trait cognitive reappraisal. Trait emotional suppression is considered a maladaptive regulatory strategy, and cognitive reappraisal an adaptive strategy (Gross & John, 2003). However, there appears to be no association between these traits and perceived reactivity to stress as expected. This may be due to weaknesses in the ERQ for use with athletes. Although previous research has found the measure of cognitive reappraisal to be associated with more pleasant emotions in athletes, the measure of emotional suppression has been found not to be conversely associated with unpleasant emotions (Uphill et al., 2012). In other words, emotional suppression may not be a maladaptive regulatory strategy in sporting contexts. Alternatively, the ERQ may not be sufficient in reflecting the suppressive strategies used by athletes. Therefore, alternative measures of trait emotion regulation may need to be explored for future research.

In study 3.2, no association between PSR and emotion regulation (indexed by HF-HRV) was found. This was despite the SECPT being perceived as stressful and PSR being associated with perceptions of stress taken immediately after the task. Moreover, stress and emotion regulation are posited to be highly related (Wang & Saudino, 2011), and HF-HRV has been shown to be a marker for both well-being and performance under pressure (Laborde et al., 2015; Mosley et al., 2017). Therefore, doubts remain over the relationship between SR and emotion regulation, and the predictive validity of PSR in relation to physiological processes of stress and emotion regulation.

6.4. Implications for future applied practice

There are several important applied implications associated with the findings in this thesis. Firstly, the PSRS-AA could be used as a screening tool to identify adolescent athletes at greatest risk of experiencing several adverse outcomes when exposed to the multitude of stressors associated with competitive youth sport (van Rens et al., 2016). Adolescent athletes at greatest risk of experiencing increased stress and both lesser satisfaction due to their higher levels of PSR could be identified and then prioritised for early interventions. The appropriate allocation of early interventions could result in better preparation for the multitude of demands young athletes are likely to encounter and could subsequently lead to a reduced risk of experiencing higher levels of stress, negative emotions, dissatisfaction, and performance decrements. Such interventions could have implications for reducing levels of drop-out from youth sport due to stressors experienced in and around sporting environments. Future research with an applied focus could examine which interventions are effective in bringing about long-term changes in adolescent athletes' perceptions of their SR, influencing their appraisal of stressors, and thus their emotions, coping, performance, and well-being over time.

Given the strong associations between PSRS-AA scores and appraisal, athletes with high levels of PSR may be best prioritised for cognitive-behavioural type interventions. For example, Didymus and Fletcher (2017a) conducted a cognitive-behavioural intervention akin to Cognitive-Behavioural Therapy (CBT; Beck, 2011) with four field hockey players. Over 26 weeks, participants were taught a number of cognitive re-structuring techniques in relation to organisational stressors they experienced as part of their participation in their sport and were encouraged to integrate them during their performances. Throughout the intervention, reduced threat appraisals and negative emotions, and increased challenge appraisals, positive emotions, and performance satisfaction were reported. These effects were maintained for a three-month period post-intervention (Didymus & Fletcher, 2017a). An intervention such as this would be of great use to adolescent athletes with high levels of PSR, given that they are more likely to make threat appraisals prior to competition, and experience negative emotions during competition as a result.

Moore, Vine, Wilson, and Freeman (2015) developed an 'arousal reappraisal' intervention. Participants in an experimental group were given instructions prior to completing a pressurised golf putting task, where they were encouraged to reappraise elevations in arousal as beneficial for performance. Compared to a control group given no instructions, participants demonstrated more adaptive physiological responses (increased cardiac output coupled with reduced peripheral resistance) and greater putting accuracy (Moore et al., 2015). A similar intervention could help adolescent athletes with high levels of SR to reappraise the greater levels of stress intensity they are likely to experience when exposed to stressors.

There is also a growing body of evidence supporting the efficacy of Rational Emotive Behaviour Therapy (REBT) for athletes (Turner, Slater, & Barker, 2014; Wood, Barker, Turner, & Sheffield, 2018). REBT is a cognitive-behavioural therapy that aims to identify and dispute irrational beliefs (which often cause unhealthy emotions and maladaptive behaviours) and replace them with rational beliefs (which are associated with healthy emotions and adaptive behaviours; Turner & Barker, 2014). Wood et al. (2018), in a single-case research design, delivered a five session REBT intervention to eight Paralympic athletes. Reductions in rational beliefs were coupled with a reduction in resting systolic blood pressure, improvements in performance, and the use of more approach goals post-intervention and at a 9-month follow up. REBT often addresses the perceived demands athletes place upon specific situations or stressors, akin to that of primary appraisal in Lazarus and Folkman’s (1987) appraisal-based models of coping (Wood et al., 2018). Therefore, REBT could be effective in modulating the appraisal of increased stress intensity (primary appraisal) experienced by those scoring highly on the PSRS-AA.

Given the direct effect PSR also has on emotions, more direct emotional control strategies may also be effective. For example, motivational general-arousal based imagery focuses on modulating arousal and relaxation responses to stressors (Jones, 2003). Jones and colleagues (2002) examined the effects of imagery on the emotional states of climbers, with participants who received an imagery script while on a four-session programme experiencing lower levels of perceived stress. Therefore, this type of imagery could be utilised to modulate the perceived stress responses experienced by adolescent athletes with high PSR. Alternatively, more direct somatic techniques could be employed. A systematic review of the effects of relaxation techniques on performance has supported the efficacy of biofeedback training (Pelka et al., 2016), where participant are taught relaxation techniques (such as controlled breathing) designed to modulate their arousal, while being given feedback on their physiological states.

PSR appears to have an indirect effect on coping, with high levels being associated with maladaptive coping. Therefore, a coping intervention may also be effective. Reeves, Nicholls, and McKenna (2011b) tested a ‘coping effectiveness training for adolescent soccer players’ intervention. Five adolescent soccer players received advice on cognitive-based and behavioural-based coping strategies, were asked to reflect on times when they had coped successfully and reviewed the coping strategies they employed each week for six weeks. Improvements in coping self-efficacy, coping effectiveness, subjective performance were all observed compared to baseline measures. An intervention such as this could help adolescent athletes regulate their behaviour and indirectly reduce their PSR through increased coping effectiveness influencing appraisal of future stressors.

Finally, given the association between PSR and reinvestment, interventions designed to reduce movement self-consciousness, and thus choking, under pressure could also be prioritised for athletes scoring highly on the PSRS-AA (Gröpel & Mesagno, 2017). For example, dual-task interventions have been shown to improve performance under pressure, where participants are given task-irrelevant instructions to perform during the execution of a well-learnt motor skill (see Gröpel & Mesagno, 2017 for review). These instructions reduce movement self-consciousness, and thus the likelihood of skill failure under pressure. This type of intervention could be of benefit to adolescent athletes predisposed to movement self-consciousness due to PSR.

In conclusion, adolescent athletes scoring highly on the PSRS-AA could be prioritised for several interventions to safeguard them against the adverse outcomes PSR is associated with. These interventions could help adolescent athletes reappraise the stressors they experience, to perceive them as less threatening. Alternatively, several regulatory strategies could also be employed to indirectly modulate perceived stress responses, such as imagery, relaxation, and coping interventions. Future research could examine whether such interventions would be effective in bringing about long-term change in adolescent athlete's PSR, using the PSRS-AA as a measure of intervention effectiveness.

6.5. Limitations and directions for future research

6.5.1. Review of the literature

The systematic review in chapter 2 reveals the first limitation of the research, and thus a difficulty in conducting a systematic review of 'stress reactivity'. As discussed in chapter 2, the term 'stress reactivity' was inconsistently operationalised throughout the selected literature and appears to cover a broad terminology. This made defining the search criteria for the literature review problematic. Furthermore, it is possible that many studies may have assessed stable individual differences in responses to stress without the use of the term 'stress reactivity'. Therefore, the limited number of selected studies may not reflect all of the research in this area, and thus all the associated measures and outcomes of adolescent SR. Future research may wish to resolve these issues by consistently operationalising stable individual differences in stress responses as 'stress reactivity'. Furthermore, research examining a specific construct or type of reactivity (i.e. PSR or cortisol reactivity) should also be consistent and specific with their use of terminology.

Ultimately, a measure of SR that did not feature in the reviewed literature was chosen to be adapted for the subsequent studies (the PSRS). This was despite the fact the systematic review was, partly, designed to identify a measure to be adapted for future research. One could therefore argue that the systematic review failed in one of its objectives. However, it was decided to use the PSRS given the lack of ecological validity in the measures that were reviewed in the literature, and the relative strengths of the PSRS over other available measures. Specifically, the PSRS could be adapted to reflect the multiple stress domains experienced by adolescent athletes in the real-world, not a single response to a controlled setting in a laboratory procedure. Secondly, from a pragmatic perspective, the PSRS was a less costly, less time-consuming, and less invasive measure than many of the laboratory-based procedures.

6.5.2. Validity and reliability of the PSRS-AA

Chapters 3 and 5 both conducted CFAs of the PSRS-AA and revealed acceptable model fit. However, there is potentially room for improvement for the PSRS-AA given some of the findings. Although internal consistency (using Cronbach's alpha) for the scale's overall aggregate measure of total reactivity was consistently good (.86-.87), and the two CFAs revealed acceptable model fit for the five-factor structure, the internal consistency of the subscales was low and unsatisfactory across the studies (.51-.73). This would suggest that although the overall scale is reliable for measuring total reactivity, the subscales may not be reflective of the stress domains adolescent athletes experience, and therefore not a valid measure for adolescent athletes. Study 3.2 of chapter 5 did use the RSE subscale in isolation, however in that case it did produce satisfactory reliability ($\alpha = .78$).

Although the stress domains featured in the PSRS-AA are similar to the stressors experienced by adolescent athletes (Reeves et al., 2011a; van Rens et al., 2016), future research may wish to confirm whether the stressors adolescent athletes experience truly fit within these domains. The stressors experienced by a sample of adolescent's athletes could be recorded over time and then analysed in relation to the stress domains proposed by the PSRS (reactivity to social evaluation, social conflict, failure, work overload, and prolonged reactivity). Alternatively, further qualitative interviews with adolescent athletes could be conducted to confirm the presence of these different stress domains. If the stressors experienced in fact differ from these domains, modifications could be made to the subscales within the PSRS-AA to reflect this. Further analysis would help to confirm the validity of the PSRS-AA as a measure of PSR that reflects stimulus response specificity. Furthermore, if greater reliability could be confirmed via Cronbach's alpha scores, further research could conduct analyses using the individual subscales.

This programme relied heavily upon methods centring around Cronbach's alpha and factor analysis (i.e. classical test theory), as these have been predominantly used in previous related literature (Uphill et al., 2012; van Rens et al., 2016). It is acknowledged that there are criticisms in the use of Cronbach's alpha scores for assessing scale reliability (Sijtsma, 2009; Trizano-Hermosilla & Alvarado, 2016). For example, it has been argued that alpha can be shown to be unrelated to the internal structure of any given test (Sijtsma, 2009). A number of alternative methods could therefore have been used to examine and validate the scale. Methods from item response theory, such as item slopes could be utilised. Item slopes can be used to relate an item to a latent trait, and thus capture the ability of the item to discriminate between people who are high or low on the latent trait being investigated (Griffith et al., 2009).

This would allow for a greater distinction and certainty between respondents measuring low in reactivity and those who measure highly.

Alternatively, Rasch analysis could be conducted to examine the scale, support its validity, or make adaptations to improve it (Boone, 2016). For multiple-choice surveys, Rasch analysis considers the unequally differing levels of agreeableness (or difficulty) between items. In other words, there may be an item on the PSRS-AA which most respondents, whether high or low reactors, rate with a low score, while another item is consistently rated with a high score. Rasch analysis involves the construction of a Wright Map, which requires a predicted ranking of items from most agreeable to least agreeable. If the test's items accurately define a variable, there will be an equal spread of data across the Wright Map in the predicted order. If scores for an item do not match the Wright Map, the item may be deleted. Furthermore, if there is a gap in the data in comparison to the Wright Map, an item may be added in this location to fill the space. Given that the PSRS-AA produces a positive skew of results, with most respondents rating themselves as low in PSR, Rasch analysis could be used in order to adapt the scale and remove some of the items which produce mainly low scores, and thus correct the distribution of data.

Overall, this programme relied heavily on Cronbach's alpha and factor analysis to confirm the validity and reliability of the PSRS-AA. Despite its popularity in previous research, there are recognised limitations to such an approach (Sijtsma, 2009; Trizano-Hermosilla & Alvarado, 2016). Therefore, future research may wish to explore the use of alternative methods to confirm the validity and reliability of the scale, such as Item Response Theory and Rasch Analysis.

6.5.3. Validity and reliability of appraisal and coping measures

Findings also bring into question the use of other self-report measures, specifically in study 2. The measures of relational meaning challenge and threat prior to competition were positively correlated within the sample of adolescent athletes, suggesting that competitions were often appraised as both a challenge and a threat. Furthermore, secondary appraisals of control were not associated with either challenge or threat. This is inconsistent with theory regarding stress appraisal, with stressful encounters typically being appraised as either a challenge or a threat (dichtonous concepts), and these appraisals being highly dependent on perceived control and coping resources (Lazarus, 1999; Lazarus & Folkman, 1987). The single item VAS measures used to assess relational meaning may have lacked the depth required to capture adolescent athletes appraisals of the impending competition. Alternatively, given that athletes encounter multiple stressors prior to competition other than the performance itself (Mellalieu et al., 2009), measuring competition appraisals exclusively may have overlooked numerous other stressors that may have influenced emotions and coping. In addition, future research should explore whether challenge and threat appraisals can co-exist. It seems a reasonable proposition, that a stressful event has both a threat and challenge component and that they are not independent constructs.

The CICS, used to measure coping, also produced unexpected findings. Task-orientated coping positively correlated with the use of distraction orientated coping. This was unexpected, given that task-orientated coping is considered adaptive, while distraction-orientated coping is considered maladaptive (Gaudreau & Blondin, 2002). Furthermore, out of the nine discrete task-orientated coping strategies, only two (effort and mental imagery) correlated with performance satisfaction. However, athletes have been known to use a wide variety of different coping strategies, all varying in effectiveness depending upon situational demands and individual differences (Nicholls et al., 2007; Nicholls & Polman, 2007). Some coping strategies rated as effective by athletes are not always associated with increased performance (Didymus & Fletcher, 2017b).

These findings may also support the notion that adolescents do not appraise and cope with stress in the same way adults do (Compas et al., 2001; Davis & Compas, 1986). Therefore, future research may wish to further explore measures of stressor appraisals and coping, in order to confirm their validity for use with adolescent athletes.

6.5.4. PSR and physiology

This thesis did not find an association between self-reported PSR (using both the PSRS and PSRS-AA) and a physiological index of stress and emotion regulation (HF-HRV). This could indicate that there is no association between the construct of PSR and the physiological processes of stress adaptation and emotion regulation, or that the stress stimuli used in the SECPT was insufficient in provoking significant changes in HF-HRV.

Physiologically, HF-HRV reflects para-sympathetic responses of the ANS and is an index of emotion regulation (Thayer et al., 2012). Vagal activity has also been cited as a mediator of allostasis and thus are marker of physiological adaptation to stressors (McEwen & Seeman, 1999). The sympathetic nervous system is arguably more related to SR, given that it indexes acute physiological responses to stressors (Nater & Rohleder, 2009). Furthermore, individual differences in SR could be more closely related to bio-markers of allostatic load (such as cortisol levels or blood pressure), rather than indicators of allostasis and adaptation (i.e. vagal activity). HF-HRV, however, was chosen as a physiological index as it was thought it would also provide a greater insight into how PSR is associated with emotion regulation and adaptation in student athletes and non-athletes. Based on the findings it would suggest that HF-HRV is not the most suitable measure for validating whether the PSRS-AA is an alternative to physiological measures of SR. Therefore, future research could examine the association between PSR and sympathetic responses to a controlled stressor such as skin conductance or salivary alpha amylase. Alternatively, cortisol sampling could also be utilised to examine if the scale predicts neuroendocrine responses of the HPA, rather than physiological responses of the ANS. Furthermore, such methods could help to establish whether adolescent athletes scoring highly on the PSRS-AA experience greater allostatic load, and thus whether they are at greater risk of long-term adverse outcomes such as emotion dysregulation, attention impairments, and stress-related illnesses. Cortisol responses to the Trier Social Stress Test (Kirschbaum et al., 1993) have demonstrated an association with PSRS scores in previous research (Schlotz, Hammerfald, et al., 2011).

The SECPT utilised in chapter 5 may not have been suitably stressful enough to produce large enough changes in HF-HRV to compare with PSRS scores. The SECPT was chosen as a procedure as it reflected both social evaluation and physical challenge, akin to a sports performance. However, there were no significant changes between baseline and task levels of HF-HRV. On the other hand, PSRS scores were associated with participants perceptions of how stressful and painful the task was, and there were significant associations between these perceptions and HF-HRV recorded during the task. In other words, PSRS scores and HF-HRV were both associated with appraisals of stress and pain, but not with each other. Therefore, it is possible that the baseline stages of the SECPT were also stressful for participants, despite not being ‘recorded’ by the video camera or having their hand submerged, hence the lack of a significant change in HF-HRV. Sitting in a laboratory with researchers and having to sit still may have been stressful for participants in and of itself, and thus prompted a level of HF-HRV that was not reflective of a baseline measure. Future research using physiological measures of SR and HF-HRV may therefore wish to consider the validity the baseline measures they employ, to ensure that they are not appraised as stressful by participants.

If future research demonstrates PSR to be an insufficient replacement for physiological measures, one could aim to develop more ecologically valid physiological measures of individual differences in SR for athletic contexts. Sport-specific measures of individual differences in physiological reactivity, however, would have to address a number of limitations: 1) protocols must reflect the multiple stress domains experienced in adolescent athletic contexts (or even within specific sports) not single stressors generalised to all domains; 2) the stability of these measures would need to be tested over time, in order to confirm them as a trait measure, rather than a state measure; 3) If SR is to be assessed during real-world sporting tasks that are not static in nature, measures will need to delineate between increases in arousal from the physical demands of the task and SR; 4) The predictive validity of the measure would need to be confirmed in relation to number of outcomes over time, such as well-being, perceived stress, and long-term performance.

6.5.5. PSR and emotion regulation

Despite a theoretical perspective that would anticipate PSR and emotion regulation to be highly related (Wang & Saudino, 2011), the association between the two constructs in this thesis was equivocal. It is therefore unclear as to how PSR impacts upon the way in which adolescent athletes regulate their emotions, either explicitly or implicitly. This is problematic for the criterion and predictive validity of the PSRS-AA. This lack of equivocal findings may be due to the measures of emotion regulation that were used in chapter 5. Although the ERQ produced good model fit, previous research using athletic samples have criticised its validity (Uphill et al., 2012). The use of just two regulatory strategies within the ERQ (cognitive reappraisal and emotional suppression) may be too simplistic a representation of how young athletes regulate their emotions. Furthermore, despite it being considered in the general population to be maladaptive, emotional suppression may be an adaptive form of emotion regulation for athletes during competition in the short term. In the coping literature, distraction-orientated coping, a cluster of suppressive strategies, has been cited by adolescent athletes as being an effective approach to coping with stressors (Nicholls et al., 2009). The ERQ, however, was employed due to its association with a popular theory of individual differences in emotion regulation (Gross & John, 2003).

Future research could explore the implicit and explicit emotion regulation strategies used by adolescent athletes and select or develop an alternative measure to the ERQ. An alternative measure could then be used to examine the association between PSR and trait emotion regulation. For example, the Difficulties in Emotion Regulation Scale (Gratz & Roemer, 2004), rather than assessing the use of regulatory strategies, assesses numerous aspects of emotional dysregulation (such as impulse control difficulties and difficulties engaging in goal directed behaviour). One would stand to assume that greater levels of PSR, being reflective of a number of maladaptive processes and outcomes, would relate moderately to strongly to greater levels of emotional dysregulation. Therefore, an exploration of alternative measures of emotion regulation may shed more light on the relationship between PSR and the way in which adolescent athletes regulate their emotions. If an association cannot be found between PSR and emotion regulation, there would be significant doubts over the validity if the construct and thus the PSRS-AA, given that neural networks associated with SR and emotion regulation are intertwined (Wang & Saudino, 2011).

6.5.6. Longitudinal studies and predictive validity

More research is required to support the predictive validity of the PSRS-AA over time. The research presented in this thesis is predominantly cross-sectional in nature. Therefore, it is unclear as to whether the PSRS-AA can predict adverse outcomes over-time, or whether PSR is merely related to them. Therefore, more longitudinal studies could be employed to investigate the PSRS-AA's predictive validity throughout adolescence. However, given recent recommendations to expand the considered age range of adolescence to 10-25 years of age (Sawyer et al., 2018), conducting such a study with adolescent athletes over this time-span would be extremely time-consuming and costly. If adolescent athletes' PSRS-AA scores were to be assessed over time, and considering the developmental mismatch, one would expect to see PSR increase in early adolescence (as reactivity of the amygdala and limbic structures increases), and then decrease during late adolescence as the regulatory capacity of the pre-frontal cortex catches up, and the adolescent's repertoire of coping strategies increases (Ahmed et al., 2015; Compas et al., 2001).

Furthermore, research is required to explore whether the PSRS-AA can predict the success athletes experience in later life. Chapter 4 failed to demonstrate an effect of PSR on a single subjective performance. However, PSR may still influence athletic performance over-time, and whether youth athletes successfully transition to adult level. An inability to cope with stress has been cited as one of the main reasons talented athlete's fail to fulfil their potential in later life (Holt & Dunn, 2004). Therefore, with PSR being associated with more negative emotions and maladaptive coping, it would stand to reason that athletes scoring highly on the PSRS-AA during adolescence would be likely to find the stressors they experience more intense and more challenging when transitioning to adult level. Research such as this would help support the predictive validity of the scale.

6.5.7. Development of PSR

This programme of research aimed to examine the outcomes associated with individual differences in PSR, measured using the PSRS-AA. Future research could look to explore the factors which contribute to the development of PSR in adolescence. This would provide a blueprint for practitioners and organisations to understand what developmental factors contribute to some athletes being more reactive to stressors than others, and thus at greater risk of experiencing some of the adverse outcomes outlined in this research.

Maturational variables have been found to predict how adolescent athletes cope with stressors (Nicholls et al., 2015; Nicholls et al., 2013; Nicholls et al., 2009). Specifically, greater levels of pubertal, emotional, and cognitive-social maturity have been associated with greater coping effectiveness in adolescent athletes. Given the biological nature of individual differences in SR and how it develops during adolescence (Romeo, 2010), an adolescent athlete’s level of pubertal maturity could be associated with their PSR. In other words, one would expect athletes with a greater level of pubertal maturity will likely have lower levels of PSR. Moreover, given that PSR demonstrates a direct association with emotion, emotional maturity may also relate to an adolescent athlete’s level of PSR, with more emotionally mature athletes displaying lower levels of reactivity. It is possible that the effect of maturation on coping behaviours in adolescent athletes could be explained by the relationship between these variables and PSR.

SR has been associated with exposure to acute stress during childhood and adolescence (Hughes et al., 2017; Romeo, 2010). Research has already identified the experience of adverse life events to be associated with cardiovascular responses to pressurised sporting tasks (Moore, Young, Freeman, & Sarkar, 2017). Future research could examine whether adverse life events predict the development of individual differences in adolescent or adult athletes' PSR, using the PSRS-AA. These adverse events could be associated with life in general or could be of a sport specific nature. For example, increasing attention is being paid towards athletes' experiences of emotional abuse and its impact on well-being (Kavanagh et al., 2016). A measure of athletes' experiences of emotional abuse within sporting contexts could be used to examine its effects on the development of PSR. With exposure to chronic stress leading to changes in the development of physiological and neuro-endocrine systems, and the upregulating of reactivity (Boyce & Ellis, 2005; Hughes et al., 2017), one would assume that young athletes exposed to greater chronic stress during their development will likely experience greater levels of SR during adolescence and in later life.

In conclusion, this thesis has opened up many avenues for future research. To address some of the limitations of this thesis, future research should more clearly define 'stress reactivity' when examining individual differences in responses to stress. Further research should also look to further explore the validity of the PSRS-AA in relation to its association with physiological measures of SR. This would include the employment of alternative lab procedures to the ones used in this thesis, such as the Trier Social Stress Test (Kirschbaum et al., 1993), and employment of alternative measures such as skin conductance responses. Future research could also examine further the relationship between PSR and emotion regulation and explore the use of alternative measures of emotion regulation in athletic populations. Finally, having established some of the outcomes associated with PSR, the developmental and environmental factors that influence the shaping of an adolescent athlete's SR may now be examined. These may include maturational variables, such as pubertal or emotional maturity, or the athlete's prior exposure to adverse life events or even abuse.

6.6. Conclusions

This thesis makes significant and novel contributions to theory, methodology, and applied practice. The PSRS-AA provides a valid and reliable measure of adolescent athletes' individual differences in PSR. Although not a replacement for physiological measures of SR, it provides measure of the construct of PSR, a disposition underlying psychological responses to stress. The PSRS-AA provides an insight into a young athletes' typical reactions to a number of different situations they may encounter, rather than a single response to a lab stressor lacking ecological validity. The PSRS-AA predicts several psychological responses, including stressor appraisals, emotions, and coping. Furthermore, PSRS-AA scores are associated with adverse outcomes, including greater stress levels and lesser well-being.

At a theoretical level, this thesis provides several insights into the role of PSR and individual differences in the development of adolescent athletes and opens further avenues for future research. Contextualised within Lazarus and Folkman's (1987) transactional model of stress and coping, PSR has been demonstrated to be a significant individual difference influencing the psychological responses to stress that adolescent athletes experience, namely appraisal, emotion, and coping. This builds upon previous research which has examined how athletes appraise and cope with stressors, and the influence of individual differences on these processes (Kaiseler et al., 2009; Kaiseler et al., 2012a; Kaiseler et al., 2012b; Nicholls et al., 2012). Its relationship with the Big 5 (particularly neuroticism and introversion) provides support for the notion that personality is related to our differential sensitivity to environmental influence (Suls &

Martin, 2005). PSR also appears to be related to trait reinvestment, implicating it as a contingency for athletes' skill breakdown under pressure.

The development of this measure has significant applied implications. The PSRS-AA can be used as a screening tool to identify adolescent athletes with high levels of PSR, and thus those who may be at the greatest risk of the adverse outcomes identified in this thesis. Therefore, these young athletes can be prioritised for early interventions (e.g., cognitive-behavioural type) to assist them with the multiple physical, emotional, and psychological demands they will experience as adolescents participating in competitive sport. Ultimately the prioritisation of early interventions to these athletes could reduce dropout from youth sport due to stress and dissatisfaction and increase the likelihood of reactive talented athletes fulfilling their potential.

The PSRS-AA's relationship with emotion regulation requires further examination. Only partial associations were observed using a measure of trait emotion regulation, and the PSRS-AA failed to predict HF-HRV responses to an SECPT (an index of emotion regulation). This is despite SR and emotion regulation sharing many of the same neural networks, and both developing during adolescence (Ahmed et al., 2015; Blakemore & Choudhury, 2006; Wang & Saudino, 2011). Therefore, future research should look to clarify the association between SR (both perceived and physiological) and emotion regulation in adolescent athletes, in order to further understand the impact, and potential risks, of SR on youth athlete development. This may include the development of more ecologically valid methods of assessing individual differences in physiological reactivity specific to sporting contexts. Alternatively, mediators of allostatic load, such as cortisol and blood pressure, could be examined in order to establish whether adolescent athletes with greater levels of PSR are at a greater risk of the long-term consequences of increased allostatic load, such as emotion dysregulation and stress-related illnesses.

Future research should also look to examine the factors that develop SR before and during adolescence in athletes. These may include maturational variables, adverse life events, and exposure to emotional abuse and acute stress. Further research could also use the PSRS-AA longitudinally, in order to examine the development of adolescent athletes' PSR over time. This future line of research will help further understand how PSR develops in athletic populations, and how best to safeguard against the adverse processes and outcomes which contribute to talented athletes failing to fulfil their potential.

Overall, the programme of research has provided a new measure of a construct yet be examined within sport psychology research. PSR has significant ramifications for the development and well-being of adolescent athletes. The PSRS-AA provides a tool for researchers and practitioners to identify adolescent athletes mostly likely to experience a number of adverse outcomes when exposed to stressors, and who would most benefit from psychological support and interventions. As a result, levels of burnout and dropout from youth sport from stress and reduced satisfaction can be addressed taking this individualised approach.

6.7 Executive summary

This programme of research is the first of its kind to establish individual differences in SR within sporting research, influencing the performance and well-being related outcomes experienced by adolescent athletes. Specifically, individual differences in SR have been found to be associated with greater perceived stress, lower life satisfaction, lower emotional stability, and greater movement self-consciousness (associated with performance breakdown under pressure) in adolescent athletes. SR has also been found to influence the stress and coping processes of adolescent athletes, via appraisals of increased stress intensity and decreased perceived control, more negative emotions, and more maladaptive coping.

The adapted version of the PSRS by Schlotz and colleagues (the PSRS-AA) provides a valid self-report measure of adolescent sportspeople's individual differences in PSR. The scale can act as an alternative to costly, invasive, and time-consuming lab-based procedures. Furthermore, the PSRS-AA reflects reactivity to a range of stress domains applied to sporting contexts (e.g. social evaluation, failure), providing greater external validity for researchers and practitioners working in sport. The PSRS-AA can therefore be used to help identify adolescent athletes at risk of experiencing the negative performance and well-being related outcomes identified within this thesis.

Future research is required to establish whether the PSRS-AA is capable of predicting short and long-term physiological responses and adaptations to stress which can significantly impact upon the health of young athletes. This would help to further strengthen the validity of the PSRS-AA as self-report alternative to physiological measures of SR. Further research is also required to establish the developmental antecedents of individual differences in SR among adolescent athletes. For example, exposure to stress and adversity in early childhood within sporting contexts, and the experience of support received, is likely to impact upon the development of reactivity among young athletes later in adolescence and in adulthood.

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8. Appendix

Appendix 1: The Perceived Stress Reactivity Scale (Schlotz, Yim, et al., 2011)

The Perceived Stress Reactivity Scale

Instructions: This questionnaire asks about your reactions to situations which you may have experienced in the past. Three answers are suggested. Please indicate the answer that most closely describes your own reaction in general. Please don't skip any item, even if it may be hard to find the best answer.

1. When tasks and duties build up to the extent that they are hard to manage . . .
   - I am generally untroubled
   - I usually feel a little uneasy
   - I normally get quite nervous

2. When I want to relax after a hard day at work . . .
   - This is usually quite difficult for me
   - I usually succeed
   - I generally have no problem at all

3. When I have conflicts with others that may not be immediately resolved . . .
   - I generally shrug it off
   - It usually affects me a little
   - It usually affect me a lot

4. When I make a mistake . . .
   - In general, I remain confident
   - I sometimes feel unsure about my abilities
   - I often have doubts about my abilities

5. When I'm wrongly criticized by others . . .
   - I am normally annoyed for a long time
   - I am normally annoyed for a short time
   - In general, I am hardly annoyed at all

6. When I argue with other people . . .
   - I usually calm down quickly
   - I usually stay upset for some time
   - It usually takes me a long time until I calm down

7. When I have little time for a job to be done . . .
   - I usually stay calm
   - I usually feel uneasy
   - I usually get quite agitated

8. When I make a mistake . . .
   - I am normally annoyed for a long time

  - I am normally annoyed for a while
  - I generally get over it easily

9. When I am unsure what to do or say in a social situation . . .
   - I generally stay cool
   - I often feel warm
   - I often begin to sweat

10. When I have spare time after working hard . . .
    - It often is difficult for me to unwind and relax
    - I usually need some time to unwind properly
    - I am usually able to unwind effectively and forget about the problems of the day

11. When I am criticized by others . . .
    - Important arguments usually come to my mind when it is too late to still make a point
    - I often have difficulty finding a good reply
    - I usually think of a reply to defend myself

12. When something does not go the way I expected . . .
    - I usually stay calm
    - I often get uneasy
    - I usually get very agitated

13. When I do not attain a goal . . .
    - I usually remain annoyed for a long time
    - I am usually disappointed, but recover soon
    - In general, I am hardly concerned at all

14. When others criticize me . . .
    - I generally don’t lose confidence at all
    - I generally lose a little confidence
    - I generally feel very unconfident

15. When I fail at something . . .
    - I usually find it hard to accept
    - I usually accept it to some degree
    - In general, I hardly think about it

16. When there are too many demands on me at the same time . . .
    - I generally stay calm and do one thing after the other
    - I usually get uneasy
    - Usually, even minor interruptions irritate me

17. When others say something incorrect about me . . .
    - I usually get quite upset
    - I normally get I little bit upset
    - In general, I shrug it off

18. When I fail at a task . . .
    - I usually feel very uncomfortable
    - I usually feel somewhat uncomfortable
    - In general, I don't mind

19. When I argue with others . . .
    - I usually get very upset
    - I usually get a little bit upset
    - I usually don't get upset

20. When I am under stress . . .
    - I usually can't enjoy my leisure time at all
    - I usually have difficulty enjoying my leisure time
    - I usually enjoy my leisure time

21. When tasks and duties accumulate to the extent that they are hard to cope with . . .
    - My sleep is unaffected
    - My sleep is slightly disturbed
    - My sleep is very disturbed

22. When I have to speak in front of other people . . .
    - I often get very nervous
    - I often get somewhat nervous
    - In general, I stay calm

23. When I have many tasks and duties to fulfil . . .
    - In general, I stay calm
    - I usually get impatient
    - I often get irritable

Note. The first answer category of each item is coded 0, the second 1, and the third 2. Items marked with "R" are to be reversed (reverse score 2 original score). Prolonged Reactivity (PrR): 2R, 10R, 20R, 21; Reactivity to Work Overload (RWO): 1, 7, 12, 16, 23; Reactivity to Social Conflict (RSC): 3, 5R, 6, 17R, 19R; Reactivity to Failure (RFa): 8R, 13R, 15R, 18R; Reactivity to Social Evaluation (RSE): 4, 9, 11R, 14, 22R; Perceived Stress Reactivity total score (PSRS-tot): sum of the five scale scores.

Appendix 2: The Perceived Stress Reactivity Scale for Adolescent Athletes (Britton et al., 2017)

The Perceived Stress Reactivity Scale for Adolescent Athletes

Instructions: This questionnaire asks about your reactions to situations **related to taking part in your sport** which you may have experienced in the past. Three answers are suggested. Please tick the answer that most closely describes your own reaction in general to these situations in your sport. Please don't skip any question, even if it may be hard to find the best answer.

1. When all my different training sessions and matches build up and become hard to manage.
    - I am generally untroubled.
    - I usually feel a little uneasy.
    - I normally get quite nervous.

2. When I want to relax after a hard training session or match.
    - This is usually quite difficult for me.
    - I usually succeed.
    - I generally have no problem at all.

3. If I have conflicts with team-mates, coaches or officials.
    - I generally shrug it off.
    - It usually affects me a little.
    - It usually affects me a lot.

4. When I make a mistake.
    - In general, I remain confident.
    - I sometimes feel unsure about my abilities.
    - I often have doubts about my abilities.

5. When I'm wrongly criticized by others.
    - I am normally annoyed for a long time.
    - I am normally annoyed for a short time.
    - In general, I am hardly annoyed at all.

6. If I argue with team-mates, coaches or officials.
    - I usually calm down quickly.
    - I usually stay upset for some time.
    - It usually takes me a long time until I calm down.

7. When I have little time to prepare for a match.
    - I usually stay calm.
    - I usually feel uneasy.
    - I usually get quite unsettled.

8. When I make a mistake.
    - I am normally annoyed for a long time.
    - I am normally annoyed for a while.
    - I generally get over it easily.

9. When I am unsure what to do or say in front of my team-mates or coaches.
    - I generally stay cool.
    - I often feel like I'm blushing.
    - I often begin to sweat.

10. When I have spare time after training or playing hard.
    - It is often difficult for me to relax.
    - I usually need some time to relax properly.
    - I am usually able to relax well.

11. When I am criticized by others.
    - I usually fail to find a reply to defend myself
    - I often have difficulty finding a good reply.
    - I usually think of a reply to defend myself.

12. When something does not go the way I expected.
    - I usually stay calm.
    - I often get uneasy.
    - I usually get very upset.

13. When I do not achieve a goal.
    - I usually remain annoyed for a long time.
    - I am usually disappointed, but recover soon.
    - In general, I am hardly concerned at all.

14. When others criticize me.
    - I generally don't lose confidence at all.
    - I generally lose a little confidence.
    - I generally feel very unconfident.

15. When I fail at something.
    - I usually find it hard to accept.
    - I usually accept it to some degree.
    - In general, I hardly think about it.

16. When there are too many things related to my sport that I have to do at the same time.
    - I generally stay calm and do one thing after the other.
    - I usually get uneasy.
    - Usually, even minor interruptions irritate me.

17. When others say something incorrect about me.
    - I usually get quite upset.
    - I normally get a little bit upset.

- In general, I shrug it off.

18. When I fail at a task.
    - I usually feel very uncomfortable.
    - I usually feel somewhat uncomfortable.
    - In general, I don't mind.

19. If I have arguments with team-mates, coaches or officials.
    - I usually get very upset.
    - I usually get a little bit upset.
    - I usually don't get upset.

20. When I am under stress.
    - I usually don't enjoy playing my sport at all.
    - I usually have difficulty enjoying my sport.
    - I usually enjoy playing my sport.

21. When all my training sessions and matches accumulate and become hard to cope with.
    - My sleep is unaffected.
    - My sleep is slightly disturbed.
    - My sleep is very disturbed.

22. When I have to perform in front of other people.
    - I often get very nervous.
    - I often get somewhat nervous.
    - In general, I stay calm.

23. When I have to fulfil many tasks and duties related to my sport.
    - In general, I stay calm.
    - I usually get impatient.
    - I often get bad-tempered.

Note. The first answer category of each item is coded 0, the second 1, and the third 2. Items marked with "R" are to be reversed (reverse score 2 original score). Prolonged Reactivity (PrR): 2R, 10R, 20R, 21; Reactivity to Work Overload (RWO): 1, 7, 12, 16, 23; Reactivity to Social Conflict (RSC): 3, 5R, 6, 17R, 19R; Reactivity to Failure (RFa): 8R, 13R, 15R, 18R; Reactivity to Social Evaluation (RSE): 4, 9, 11R, 14, 22R; Perceived Stress Reactivity total score (PSRS-tot): sum of the five scale scores.

Appendix 3: The Perceived Stress Scale (Cohen et al., 1983)

The questions in this scale ask you about your feelings and thoughts during the last month. In each case, you will be asked to indicate by circling how often you felt or thought a certain way.

0 = Never 1 = Almost Never 2 = Sometimes 3 = Fairly Often 4 = Very Often

1. In the last month, how often have you been upset because of something that happened unexpectedly?................................. 0 1 2 3 4

2. In the last month, how often have you felt that you were unable to control the important things in your life? 0 1 2 3 4

3. In the last month, how often have you felt nervous and “stressed”? 0 1 2 3 4

4. In the last month, how often have you felt confident about your ability to handle your personal problems? 0 1 2 3 4

5. In the last month, how often have you felt that things were going your way?.. 0 1 2 3 4

6. In the last month, how often have you found that you could not cope with all the things that you had to do? 0 1 2 3 4

7. In the last month, how often have you been able to control irritations in your life?... 0 1 2 3 4

8. In the last month, how often have you felt that you were on top of things?.... 0 1 2 3 4

9. In the last month, how often have you been angered because of things that were outside of your control?.................................. 0 1 2 3 4

10. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them? 0 1 2 3 4

Appendix 4: Ten item personality inventory (Gosling et al., 2003)

Here are a number of personality types that may or may not describe. Please place an "X" in the one box that best indicates how much you agree or disagree with that personality type being like you. There are no right or wrong answers.

	I see myself as…	**Disagree strongly**	**Disagree moderat ely**	**Disagree a little**	**Neither agree nor disagree**	**Agree a little**	**Agree moderate ly**	**Agree strongly**
1	Out-going, enthusiastic							
2	Critical, argumentative							
3	Dependable, self-disciplined							
4	Anxious, easily upset							
5	Open to new experiences, complex							
6	Reserved, quiet							
7	Sympathetic, warm							
8	Disorganised, careless							
9	Calm, emotionally stable							
10	Conventional, uncreative							

Appendix 5: Brief measure of student life satisfaction scale with additional 'sport experience' item (Athay et al., 2012; van Rens et al., 2016)

Please place an "X" in the one box that best indicates how satisfied or dissatisfied you CURRENTLY are with each item below. There is no right or wrong answer.

	HOW SATISFIED OR DISSATISFIED ARE YOU WITH…	**Very Dissatisfied**	**Somewhat Dissatisfied**	**Neither Satisfied Nor Dissatisfied**	**Somewhat Satisfied**	**Very Satisfied**
1.	Your family life					
2.	Your friendships					
3.	Your school/education experience					
4.	Yourself					
5.	Where you live					
6.	Your sport experience					
7.	Your life overall					

Appendix 6: VAS stress appraisal measures

Put a line or a cross through the scales below where you think it best represents how you feel right now based on the questions. There are no right or wrong answers. Just answer with your honest opinion.

1. **How stressful is this match?**

Not at all ⟷ Extremely stressful

2. **How in control do you feel?**

No control ⟷ Total control

3. **How much of a threat is this match to you?**

Not at all a threat ⟷ Very much a threat

4. **How much of a challenge is this match to you?**

Not at all a challenge ⟷ Very much a challenge

Appendix 7: Sport Emotion Questionnaire (Jones et al. 2005)

Below you will find a list of words that describe a range of feelings that sport performers may experience. Please read each one carefully and indicate on the scale next to each item ***how you felt during the match you just played in***. There are no right or wrong answers. Do not spend too much time on any one item, but choose the answer which best describes your feelings during the match.

	Not at all	A little	Moderately	Quite a bit	Extremely
Uneasy	0	1	2	3	4
Upset	0	1	2	3	4
Exhilarated	0	1	2	3	4
Irritated	0	1	2	3	4
Pleased	0	1	2	3	4
Tense	0	1	2	3	4
Sad	0	1	2	3	4
Excited	0	1	2	3	4
Furious	0	1	2	3	4
Joyful	0	1	2	3	4
Nervous	0	1	2	3	4
Unhappy	0	1	2	3	4
Enthusiastic	0	1	2	3	4
Annoyed	0	1	2	3	4
Cheerful	0	1	2	3	4
Apprehensive	0	1	2	3	4
Disappointed	0	1	2	3	4
Energetic	0	1	2	3	4
Angry	0	1	2	3	4
Happy	0	1	2	3	4
Anxious	0	1	2	3	4
Dejected	0	1	2	3	4

Appendix 8: Coping Inventory for Competitive Sport (Gaudreau & Blondin, 2002)

Each question represents things that athletes can do or think during sport. For each question indicate the extent to which it represents what you did during your last performance. There are no right or wrong answers. Just answer as honestly as possible based upon what you did during your last match.

1	2	3	4	5
Not at all	A little	Moderately	Strongly	Very Strongly

1. I visualised that I was in control of the situation	1	2	3	4	5
2. I used swear words loudly or in my head in order to expel anger	1	2	3	4	5
3. I kept my distance from others	1	2	3	4	5
4. I committed myself by giving consistent effort	1	2	3	4	5
5. I occupied my mind in order to think things other than the match	1	2	3	4	5
6. I tried not to be intimidated by other athletes	1	2	3	4	5
7. I asked someone for advice about my mental preparation	1	2	3	4	5
8. I tried to relax my body	1	2	3	4	5
9. I analysed my last performance	1	2	3	4	5
10. I lost all hope of achieving my goal	1	2	3	4	5
11. I mentally rehearsed the execution of my movements	1	2	3	4	5
12. I got angry	1	2	3	4	5
13. I retreated to a place where it was easier to think	1	2	3	4	5
14. I gave relentless effort	1	2	3	4	5
15. I thought about another activity in order to not think about the match	1	2	3	4	5
16. I tried to get rid of my doubts by thinking positively	1	2	3	4	5
17. I asked other athletes for advice	1	2	3	4	5
18. I tried to reduce the tension in my muscles	1	2	3	4	5

19. I analysed the weaknesses of my opponents	1	2	3	4	5
20. I let myself feel hopeless and discouraged	1	2	3	4	5
21. I visualised myself doing a good performance	1	2	3	4	5
22. I expressed my discontent	1	2	3	4	5
23. I kept all people at a distance	1	2	3	4	5
24. I gave my best effort	1	2	3	4	5
25. I entertained myself in order not to think about the match	1	2	3	4	5
26. I replaced my negative thoughts with positive ones	1	2	3	4	5
27. I talked to a trustworthy person	1	2	3	4	5
28. I did some relaxation exercises	1	2	3	4	5
29. I thought about possible solutions to manage the situation	1	2	3	4	5
30. I wished the match would end immediately	1	2	3	4	5
31. I visualised my all-time best performance	1	2	3	4	5
32. I expressed my frustrations	1	2	3	4	5
33. I searched for calmness and quietness	1	2	3	4	5
34. I tried not to think about my mistakes	1	2	3	4	5
35. I talked to someone who was able to motivate me	1	2	3	4	5
36. I relaxed my muscles	1	2	3	4	5
37. I analysed the demands of the match	1	2	3	4	5
38. I stopped believing in my ability to attain my goal	1	2	3	4	5
39. I thought about my family or friends to distract myself	1	2	3	4	5

Appendix 9: VAS measure of Performance Satisfaction (Pensgaard & Duda, 2003)

Performance Satisfaction

Put a line or a cross through the scale below to best represent how satisfied you are with your performance today. There is no right or wrong answer, just your honest opinion of how satisfied you are with how you played today.

Totally Dissatisfied ⟷ Totally Satisfied

Appendix 10: The Movement Specific Re-investment Scale (Masters et al., 2005)

DIRECTIONS: Below are a number of statements about your movements in general. Circle the answer that best describes how you feel for each question.

1 I remember the times when my movements have failed me.

strongly disagree	moderately disagree	weakly disagree	weakly agree	moderately agree	strongly agree

2 If I see my reflection in a shop window, I will examine my movements.

strongly disagree	moderately disagree	weakly disagree	weakly agree	moderately agree	strongly agree

3 I reflect about my movement a lot.

strongly disagree	moderately disagree	weakly disagree	weakly agree	moderately agree	strongly agree

4 I try to think about my movements when I carry them out.

strongly disagree	moderately disagree	weakly disagree	weakly agree	moderately agree	strongly agree

5 I am self conscious about the way I look when I am moving.

strongly disagree	moderately disagree	weakly disagree	weakly agree	moderately agree	strongly agree

6 I sometimes have the feeling that I am watching myself move.

strongly disagree	moderately disagree	weakly disagree	weakly agree	moderately agree	strongly agree

7 I am aware of the way my body works when I am carrying out a movement.

strongly disagree	moderately disagree	weakly disagree	weakly agree	moderately agree	strongly agree

8 I am concerned about my style of moving.

strongly disagree	moderately disagree	weakly disagree	weakly agree	moderately agree	strongly agree

9 I try to figure out why my actions failed.

strongly disagree	moderately disagree	weakly disagree	weakly agree	moderately agree	strongly agree

10 I am concerned about what people think about me when I am moving.

strongly disagree	moderately disagree	weakly disagree	weakly agree	moderately agree	strongly agree

Appendix 11: The Emotion Regulation Questionnaire (Gross & John, 2003)

We would like to ask you some questions about your emotions, in particular, how you control (that is, regulate and manage) your emotions. The questions below involve two distinct aspects of your emotions. One is your emotional experience, or what you feel like inside. The other is your emotional expression, or how you show your emotions in the way you talk, gesture, or behave. Although some of the following questions may seem similar to one another, they differ in important ways. For each item, please answer using the following scale:

1	2	3	4	5	6	7
Strongly Disagree			Neutral			Strong Agree

1. ____ When I want to feel more *positive* emotion (such as joy or amusement), I *change what I'm thinking about*.

2. ____ I keep my emotions to myself.

3. ____ When I want to feel less *negative* emotion (such as sadness or anger); I *change what I'm thinking about*.

4. ____When I am feeling *positive* emotions, I am careful not to express them.

5. ____When I'm faced with a stressful situation, I make myself *think about it* in a way that helps me stay calm.

6. ____ I control my emotions by *not expressing them*.

7. ____When I want to feel more *positive* emotion, I *change the way I'm thinking* about the situation.

8. ____ I control my emotions by *changing the way I think* about the situation I'm in.

9. ____When I am feeling *negative* emotions, I make sure not to express them.

10. ____When I want to feel less *negative* emotion, I *change the way I'm thinking* about the situation.

Appendix 12: VAS measures of perceived stressfulness, pain, and unpleasantness

Put a line or a cross through the scales below to best represent your experience of the task

1. **How unpleasant was the task?**

Not at all ⟷ Very much

2. **How stressful was the task?**

Not at all ⟷ Very much

3. **How painful was the task?**

Not at all ⟷ Very much

Appendix 13: HF-HRV protocol materials

<u>Participant Information Sheet: Perceived reactivity and physiological responses to a cold pressor test in athletes and non-athletes</u>

You are being invited to take part in a research project. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask the researchers if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

What is the purpose of the project?
The purpose of this project is to develop a questionnaire measure of “perceived stress reactivity” for athletes and students. This is in order to help identify athletes and students who are more sensitive to stress, so that psychological support (such as stress management) can be appropriately provided to those most in need. This study is looking to examine whether our self-report questionnaire of stress reactivity predicts physical responses to a cold-water immersion test.

Why have I been chosen?
You have been chosen because you are currently a student in full-time or part-time education.

Do I have to take part?
It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep (and be asked to sign a consent form) and you can still withdraw at any time up until the point where your data becomes anonymised. You do not have to give a reason. As a Bournemouth University student, your choice whether or not to participate will not impact upon your studies. However, students enrolled on the BSc Psychology programme will receive SONA credits for participating.

What do I have to do?
You will firstly be fitted with a device which will measure your heart-rate. Two electrodes will be placed below you collar bone and rib cage (See image below).

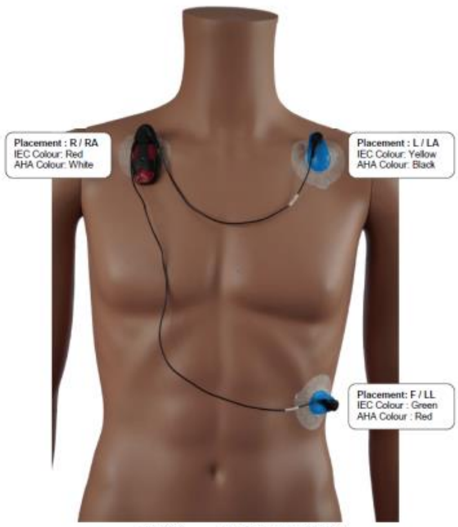

Figure 13: 3-electrode cable set placement

You will then be asked to complete two questionnaires assessing your well-being. There are no right or wrong answers, just answer the questions with your honest opinion.

You will then be seated in a chair in front of a video camera. Please keep looking at the lens of the camera throughout, even when it is not recording. Your heart-rate will be measured for 3 minutes while you are resting. Please relax but stay as still as possible. The video camera will then be switched on and you will be asked to submerge your right hand in a bucket of ice water next to you for a maximum of 3 minutes. You can withdraw your hand at any time if you feel you can no longer do so. During the task, your performance will be observed and analysed by the video camera and one of the researchers. Please continue to keep looking directly into the camera lens and remain as still as possible. At the end of the immersion task, we will turn off the camera and immediately ask you to rate your experience of the task on a series of visual scales from 0-100. We will then continue to measure you heart-rate for a further 3 minutes. Please relax and stay as still as possible. We will then remove the heart rate device and eye tracking glasses and you will be free to leave.

Are there any risks or benefits involved in taking part?
There are no known risks involved in taking part in the study. The ice water will be kept at a safe temperature between 0 and 4 degrees Celsius, and you are free to withdraw your hand if your feel you can no longer keep it submerged. Although participation will require a little of your time, it is hoped that this study will help us develop our questionnaire measure of stress reactivity. As a result, we intend to use the questionnaire to help identify athletes and students who are more sensitive to stress, so that support (such as stress management) can be provided to those most in need.

What will happen to the results of the research project?
All the information that we collect about you during the course of the research will be kept strictly confidential. You will not be able to be identified in any reports or publications. All the information collected will be used to develop the questionnaire, which will be adopted within the PhD research and publications.

For further information please contact:

Darren Britton
PhD Researcher
dbritton@bournemouth.ac.uk

Dr Emma Kavanagh
Supervisor
Lecturer in Sport Psychology and Coaching Sciences
ekavanagh@bournemouth.ac.uk

If you have any complaints about the procedure, please contact Michael Silk (msilk@bournemouth.ac.uk) or Stephen Page (spage@bournemouth.ac.uk)

Thank-you for taking the time to read through this information

Darren Britton
PhD Researcher
dbritton@bournemouth.ac.uk

Bournemouth University

Participant Agreement Form

Full title of project: Perceived reactivity and physiological responses to a cold pressor test in athletes and non-athletes

<u>Name, position and contact details of researcher:</u>

Darren Britton, PhD researcher, dbritton@bournemouth.ac.uk

<u>Name, position and contact details of supervisor:</u>

Dr Emma Kavanagh, Lecturer in Sport Psychology and Coaching Sciences,
ekavanagh@bournemouth.ac.uk

	Please Initial or Tick Here
I have read and understood the participant information sheet for the above research project.	
I confirm that I have had the opportunity to ask questions.	
I understand that my participation is voluntary.	
I understand that I am free to withdraw up to the point where the data are processed and become anonymous, so my identity cannot be determined.	
During the task or experiment, I am free to withdraw without giving reason and without there being any negative consequences.	
Should I not wish to answer any particular question(s), complete a test or give a sample, I am free to decline.	
I give permission for members of the research team to have access to my anonymised responses. I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the outputs that result from the research.	

I agree to take part in the above research project.	

________________________ ________________ ___________________________________

Name of Participant Date Signature

________________________ ________________ ____________________________________

Name of Researcher Date Signature

Demographic Questionnaire - Psychophysiological Experiment

Please answer the questions honestly. Your answers will remain anonymous.

Gender: Male / Female **Age:** _____________ **Sport**: (if applicable) _____________

	YES	**NO**
1. Have you rushed in order to arrive on time for this experiment?	❐	❐
2. Have you taken part in any intensive physical activity in the past 24 hours?	❐	❐
3. When was the last time you exercised?		
4. Have you eaten in the past two hours?	❐	❐
5. Have you consumed any caffeine in the past two hours?	❐	❐
6. Have you consumed any alcoholic beverages in the past 24 hours?	❐	❐
7. Do you usually smoke? If yes, please report the number of cigarettes you smoke on a daily basis.	❐	❐
8. Have you smoked in the past two hours?	❐	❐
9. Do you currently take any medication?	❐	❐
10. If yes, please write down the name of the medications/s?		

11. Do you have any blood pressure problems?	❒	❒
12. Did you follow your usual sleep routine last night?	❒	❒
13. When did you get up this morning?		
14. When did you go to sleep last night?		
15. Do you suffer from any mental disorders, for example severe depression or anxiety disorder?	❒	❒
16. Do you have any chronic heart issues or respiratory problems?	❒	❒
17. Do you need to use the bathroom?	❒	❒

Participant De-brief Sheet

Thank you for taking part in our study.

In order to fully debrief you in the nature of our study, we would like to make you aware of the fact that the video camera during the task was in fact **not** recording you. The presence of the video camera was solely designed to increase the level of "social evaluation stress" (i.e.: stress from being watched) you would experience during the task. This was in order to ensure that you produced a significant enough stress response for us to measure. For this to be fully effective, we could not provide you with this information before the task, as knowing the camera was not recording you would not have produced a stress response.

Please do not share this information about the task to anyone else, in case they also take part in the study in the future.

It is hoped that our self-report questionnaire of stress reactivity predicted your physical stress responses to this test, so that the questionnaire can be used as a valid alternative to lab-based tests such as these. The questionnaire can then be used to help identify athletes and students in greatest need of support coping with the stress of competitive sport and academic studies.

Please feel free to provide the researchers with any feedback about the task which you feel may improve the procedure.

Darren Britton

PhD Researcher

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