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The influence of Alexithymia and Optimism on Post-Exercise Recovery

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The influence of Alexithymia and Optimism on Post-Exercise Recovery

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Declaration

Yr wyf drwy hyn yn datgan mai canlyniad fy ymchwil fy hun yw'r thesis hwn, ac eithrio lle nodir yn wahanol. Caiff ffynonellau eraill eu cydnabod gan droednodiadau yn rhoi cyfeiriadau eglur. Nid yw sylwedd y gwaith hwn wedi cael ei dderbyn o'r blaen ar gyfer unrhyw radd, ac nid yw'n cael ei gyflwyno ar yr un pryd mewn ymgeisiaeth am unrhyw radd oni bai ei fod, fel y cytunwyd gan y Brifysgol, am gymwysterau deuol cymeradwy.

I hereby declare that this thesis is the results of my own investigations, except where otherwise stated. All other sources are acknowledged by bibliographic references. This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree unless, as agreed by the University, for approved dual awards.

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Abstract

The area of Post-Exercise recovery has gained a lot of attention in recent years, especially in applied sport settings. An athlete spends more time recovering than they do training, thus recovery is something that athletes can use to benefit them. Post-exercise recovery can incorporate both psychological (e.g. perceptions of emotions, feelings) and physiological factors (e.g. hormones, heart rate, muscular). As such the aim of this thesis was to investigate post-exercise recovery from an interdisciplinary perspective by considering the role of psychology and its effect on post-exercise recovery through both perceptual and hormonal markers. Specifically, this thesis examined the influence of personality (namely Optimism and Alexithymia) on post-exercise recovery in a range of settings (laboratory, longitudinally & around a race). Currently, the post-exercise recovery literature assuages a "one size fits all" approach and has yet to explore how individual differences in personality influence the nature of recovery, thus understanding the role personality plays in recovery has clear theoretical and applied implications.

This thesis presents three empirical studies across three chapters. The empirical chapters are prefaced by a general introduction and are brought together at the end of the thesis in the general discussion. The first empirical chapter (Chapter 2) investigated the independent effects of Alexithymia and Optimism on post-exercise recovery in an acute laboratory setting; between and after two bouts of treadmill running exercise. Post-exercise recovery was measured via questionnaire and salivary analysis of cortisol and Dehydroepiandrosterone (DHEA). Alexithymia predicted better post-exercise recovery between exercise bouts and after the second exercise bout, but poorer recovery following the second bout. Optimism failed to predict recovery either between bouts or following the second bout of exercise. These findings highlight potentially differential effects of alexithymia in different aspects of the recovery process.

The second empirical chapter (Chapter 3) investigated the personality-recovery relationship over a three-month training period amongst a sporting population. Post-exercise recovery was assessed perceptually by questionnaire and hormonally by hair cortisol, that measured the accumulation of cortisol in a three-month period. Unexpectedly no relationships were seen between either Alexithymia or Optimism and hair cortisol concentrations for the three-month period. However, Alexithymia

had a negative relationship with average perceived recovery from training over the period. Furthermore, higher levels of alexithymia were associated with higher perceptions of stress and poorer well-being. Optimism had a positive relationship with average training hours and perceived well-being and a negative relationship with perceived stress over three three-months. The findings of this chapter indicate that despite personality being associated with relevant psychological indicators associated with post-exercise recovery, these relationships are not reflected hormonally in the chronic stress biomarker hair cortisol.

The final study (Chapter 4) examined the influence of alexithymia and optimism on perceptions of post-exercise recovery during a two-week build up to, and after, a cycling race, focusing on perceptions of recovery. There were no relationships observed between either Alexithymia or Optimism with perceptions of recovery in either the before or after the cycling race.

Collectively, these studies demonstrate that personality certainly effects perceptual post-exercise recovery from exercise across a range but not all settings. The studies also demonstrate that personality has a relationship with physiological post-exercise recovery depending on the setting. These findings demonstrate that personality is worthy of further investigation within the post-exercise recovery domain.

1 General Introduction

1.1 Post- Exercise Recovery

Exercise causes the temporary disturbance of many physiological and psychological systems within the body. The post-exercise recovery period that follows an exercise session is, therefore, a fundamental component of training development. Specifically, this post-exercise recovery period allows the body to address these disturbances in preparation for the next exercise bout (Hausswirth & Le Meur, 2011). Exercise performance is well researched due to the money, incentives and recognition that may come from performing well. The need, therefore, to continually perform at an optimum level is important and as such, it is inevitable that the periods between bouts of performance need to also be investigated. This is primarily so that a better research-driven understanding of post-exercise recovery can be developed to help improve successive performances in training and competition, both acutely and longitudinally. There is a growing body of research into post-exercise recovery with the aim of helping to explain the systems behind it (Lee et al., 2017), and how to improve it (Dupuy et al., 2018; Wiewelhove et al., 2018, 2019). Notably, however, in the past, there has been a tendency to approach post-exercise recovery from a "one-size fits all" perspective, with little consideration to how individual difference variables might influence how one recovers. More recently Minett & Costello (2015) among others (Cook & Beaven, 2013; Kellmann et al., 2018; Luttrell & Halliwill, 2015; Reilly & Ekblom, 2007) state the importance of addressing post-exercise recovery on a more individualised basis. Although this has begun to be addressed (Cook & Beaven, 2013) particularly in the differences between professional and amateur (Tavares et al., 2017). Post-exercise recovery research often is still not particularly tailored to the individual (Kellmann et al., 2018) despite studies demonstrating individual differences in postexercise recovery (Cook & Beaven, 2013) and fatigue (Desmond & Matthews, 2009; Matthews, 2010). One such way in which individual differences in recovery may be addressed is differences in personality (see section 1.6) however this is yet to be researched despite being investigated considerably in fatigue in clinical settings (Abdel-Khalek, 2009; Deary & Chalder, 2008; De Vries & Van Heck, 2002) and briefly investigated in exercise fatigue (Demeersman et al., 1984).

The need to recover during post-exercise recovery is ultimately driven by fatigue which is widely accepted to be characterised as peripheral or central fatigue (Davis, 1995). The type of fatigue is dependent on its development either proximally (central) or distally (peripheral) to the neuromuscular junction in simple terms in the mind or the body (Carroll et al., 2017). As such for many years scientists have investigated both models of fatigue with the peripheral model based around impaired fatigue of the muscles and central fatigue the reduction in the capacity of the central nervous system to activate the muscles (Zajac et al., 2015). Despite a wealth of research into central and peripheral fatigue during exercise an understanding of the underlying mechanisms of whole-body fatigue remains elusive (Marino et al., 2011; Shei & Mickleborough, 2013). Ultimately for studying recovery it is therefore important to recognise a need to assess recovery from both a central and peripheral viewpoint.

Post-exercise recovery is multifaceted in nature due to the many body systems disturbed by exercise and therefore can be measured using a multitude of methods, which are often referred to as markers rather than measures of recovery (Lee et al., 2017). Hausswirth & Le Meur (2011) outline a comprehensive list of markers that are used for post-exercise recovery. Some general examples include perceptual recovery (Laurent et al., 2011), hormonal recovery (Heaney et al., 2013), subsequent performance on physical tasks (McLellan et al., 2014) and heart rate recovery (Daanen et al., 2012). A marker generally involves something over time during exercise, for example, an increase in heart rate, and then the same marker may be tracked over the recovery period to show its trajectory in the period that follows the exercise bout, for example, heart rate recovery (a decrease in heart rate). The profile of the marker used can be dictated by the time over which the researcher is investigating post-exercise recovery, whereas other markers are not entirely restricted by time. For example, perceptual recovery is a marker that indicates how recovered from exercise an individual perceives themselves to be following that exercise bout and may be recalled at a later date about a certain time-point whereas, a marker such as salivary cortisol can only reflect over a time period and has to be taken at a precise point for its value to be interpreted correctly (Vining et al., 1983). One set of markers particularly sensitive to time are hormonal markers, for example, cortisol can be measured in the moment through saliva giving a brief snapshot of the hormone (Vining et al., 1983) or in hair giving a estimated concentration for months of cortisol secretion (Wennig, 2000).

1.1.1 Cortisol and Dehydroepiandrosterone (DHEA)

Unsurprisingly exercise causes disturbances to the body's hormones (Gatti & De Palo, 2011). As exercise is considered to be a physical stressor of the body the stressor causes the body to react with a stress response and then initiates a need to recover from that stress response over time. One of the areas of the body which is disturbed during exercise is the Hypothalamic-Pituitary-Adrenal (HPA)-axis (Duclos & Tabarin, 2016).

The HPA axis is a central control and regulatory system which connects the central nervous system (CNS) and the hormonal system and stems from the hypothalamus in the brain. The HPA axis is vital in maintaining physical function, but its main role is responding to stress to help the organism adapt to demands and maintain homeostasis, (Kudielka & Kirschbaum, 2004). Upon the body being stressed the first hormone secreted by the hypothalamus is corticotropin-releasing hormone (CRH). CRH then causes the release of adrenocorticotropic hormone (ACTH) from the pituitary gland which in turn stimulates cholesterol in the adrenal cortex which is synthesised to pregnenolone. Depending on the area of the adrenal cortex the pregnenolone is synthesised into cortisol (Zona Fasciculata) or DHEA (Zona Reticularus). There is some evidence (Guilliams & Edwards, 2010; Oberbeck et al., 1998) that when the body is placed under more stress there is a shunt towards the synthesis of more cortisol (Zona Fasciculata) while the less stressed the body is the more of a shunt towards the synthesis of DHEA (Zona Reticularus) [Figure 1.1]. How regulation of the adrenal cortex zonas, sites of cortisol and DHEA synthesis, occurs and the stimulus potentially from the brain that helps the adrenal cortex zona regulate between the synthesis of the two hormones is unknown. The release of Cortisol and DHEA in response to a physical and/or psychological stressor causes the two hormones to compete to ensure the body can respond to the stressor but also recover from it and come back into homeostasis. Cortisol is solely (100%) produced in the adrenal glands through the previously described cascade whereas 80% of DHEA is produced in the adrenal glands with 20% produced in the by the testes, ovaries, and brain (Labrie et al., 2011; Peretti & Forest, 1978). Activation of the HPA axis in a sporting context depends on exercise duration and intensity (Hill et al., 2008; Luger et al., 1987; VanBruggen et al., 2011), it is generally accepted that 30 minutes of exercise above 80% VO2 max will activate the release of cortisol (Hill et al., 2008;

Luger et al., 1987; VanBruggen et al., 2011). DHEA increases during and after exercise before returning to pre-exercise concentrations approximately one-hour post-exercise (Heaney et al., 2012; Oberbeck et al., 1998).

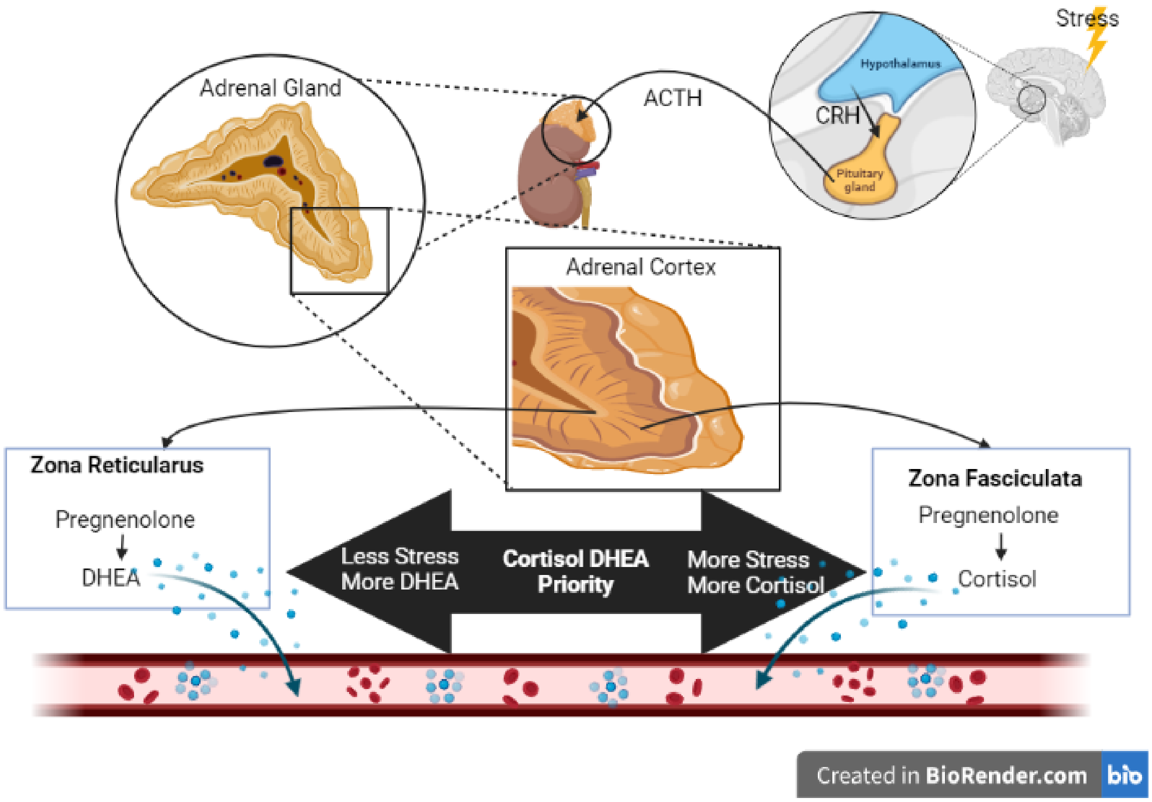


Figure 1.1: Cortisol Dehydroepiandrosterone (DHEA) regulation from hypothalmus release: When the body is under stress which hormone is prioritized changes depending on stress level. This regulation is typically represented by the Cortisol:DHEA ratio of these two hormones e.g. a typical ratio in a normal rested person is 6, under stress it is 8, Irshad et al.,2020

Cortisol is a catabolic steroid hormone that can be measured through a wide range of methods serum, urine, saliva, hair, and nail (Levine et al., 2007; Van Uum et al., 2009). In all methods except serum, the cortisol measured is free and unbound (Levine et al., 2007). Salivary cortisol has been used in a wealth of research measuring the momentary free/unbound cortisol within the body, particularly in stressful situations (Hellhammer et al., 2009; Kudielka et al., 2009). Within post-exercise recovery literature, cortisol is used as a marker of post-exercise recovery. Investigators often take several salivary measurements over a period of time at least one prior to exercise, then several sequentially at various time points after the exercise is complete (Heaney et al., 2012; Hill et al., 2008; Powell et al., 2015). These measures allow a concentration curve to be captured showing the changes in cortisol post-exercise which then return to pre-exercise concentrations showing recovery of the hormone and indirectly return to balance of the HPA axis (Gatti & De Palo, 2011). Cortisol is catabolic in nature and therefore the body finds it more difficult to build muscle and recover whilst a high concentration of cortisol is circulating. Therefore after exercise until cortisol concentrations drop it is more difficult for the body to recover and rebuild. Cortisols reduction in concentration is hence seen as a marker of recovery and allows further recovery and muscle build (Molfino et al., 2014).

A more chronic measure of cortisol concentration can be obtained from hair cortisol (Manenschijn et al., 2011; Van Uum et al., 2009). Cortisol is deposited over time into an individual's hair shafts with 1cm of growth representing approximately one month of cortisol exposure (Wennig, 2000). Hair cortisol is a relatively new method of cortisol collection, with investigation mainly being based on animals, clinical populations, and pregnant women (Greff et al., 2019; Russell et al., 2012). Recently however hair cortisol has been explored within sporting populations to investigate sporting populations hair cortisol concentrations in comparison to controls. This research demonstrated that amateur athletes had higher cortisol concentrations in comparison to those who did not exercise (Gerber et al., 2012; Skoluda et al., 2012). This research has been further extended in military research with two studies investigating changes in hair cortisol concentration over the training period of military recruits (Boesch et al., 2015; Gifford et al., 2019). The results among military recruits differed with military training increasing hair cortisol concentrations only in females (Gifford et al., 2019) and not males (Boesch et al., 2015). Although hair cortisol has not been investigated within the post-exercise recovery literature to date, its inclusion in post-exercise recovery research may enable investigators to measure cortisol concentrations more chronically over time, for example, weeks and months. While such a method lacks the momentary acuity of saliva cortisol, it can instead offer researchers a more practical and cost-effective way of measuring cortisol in scenarios where repeated saliva sampling over weeks or months might be costly or impractical.

DHEA and its sulfate DHEA(S) are the most abundant steroid hormone in the human body, however, it is not as widely studied as glucocorticoids (Kroboth et al., 1999). DHEA is an anabolic steroid that again can be measured through a wide range of methods such as serum, urine, saliva, and hair. DHEA again has been used in a wealth of stress-related research (Dutheil et al., 2021) however it has not been investigated to the same extent that cortisol has in a post-exercise recovery setting. Within stress research, DHEA has been shown to increase from baseline during a stressor and then decline over time after the stressor (Dutheil et al., 2021; Lennartsson, 2013, 2013; Lennartsson et al., 2012). Meta-analytic research has revealed that DHEA decreases after the stressor with no significant change coming post 1hr after a stressor (Dutheil et al., 2021). DHEA is arguably of equal importance to cortisol during post-exercise recovery due to its ability to help return balance to the HPA Axis. DHEA being anabolic in nature has the opposite role to cortisol in the body and will allow the body to recover and build, (Villareal & Holloszy, 2006).

It is of note that both cortisol and DHEA are needed in the body and although cortisol may be regarded as detrimental in some respects (Jefferies, 1991; Kandhalu, 2013; Sauro et al., 2009; Shields et al., 2017), it is essential for preparing the body to move and be active (Hackney et al., 2008). The essential need for cortisol is seen in cortisol's diurnal rhythm which starts with cortisol awakening response to help the body wake up and start moving for the day. In exercise scenarios, it has been shown that there can be an anticipatory cortisol response to prepare the body ready to exercise (for review see Paridon et al. (2017)). Cortisol and DHEA need to work efficiently for the body to respond most appropriately or to recover appropriately. A malfunctioning HPA axis over longer periods has the potential to cause allostatic overload. First described by Sterling & Eyer (1988) in the cardiovascular literature, Allostasis means "maintaining stability (or homeostasis) through change". Allostasis is the ability to turn adaptive systems on and off again efficiently, helping the body to cope and adapt to the stresses of the world (McEwen, 2004). Chronic imbalances can lead to an increased allostatic load (McEwen, 1998). Allostatic load can be an inadequate response, too frequent response, or failure of a system to stop responding (McEwen, 1998). Athletes are potentially at risk of both training and life stress increasing the frequency at which the neuroendocrine system must respond, and individuals may be unable to cope and be at risk from excessive allostatic load. Allostatic load could then, in turn, lead to reduced performance (Angeli et al., 2004) and possibly even the physical and mental health problems that are associated with allostatic load such as chronic conditions, poorer well-being, greater stress, poor cardiovascular health and psychological disorders (Beckie, 2012; Guidi et al., 2021;

Juster et al., 2010).

Both cortisol and DHEA are used as biomarkers of allostatic load (Juster et al., 2010). In some literature, cortisol and DHEA have also been investigated as a ratio. Investigating cortisol and DHEA as a ratio allows analysis of the balance of the HPA axis, due to co-synthesis of the hormones and the opposing effects they have on the body (Kamin & Kertes, 2017). For example, high concentrations of cortisol may not necessarily be detrimental if concentrations of DHEA are also high. The ratio allows evaluation of which areas of the adrenal cortex are being prioritised and therefore which area is prioritised to synthesise pregnenolone into its respective hormone (zona glomerulosa = aldosterone, zona fasciculata = cortisol and zona reticularis = DHEA). How which adrenal area is prioritised (sometimes called "pregnenolone steal") is not yet fully understood. Cortisol and DHEA are synthesised in separate areas of the adrenal cortex, and therefore it is not competition for the same pool of pregnenolone. However, how the prioritisation of an area to make cortisol or DHEA happens is not fully understood (Guilliams, 2015; Guilliams & Edwards, 2010). The ratio has mainly been explored outside of an exercise environment, however, research has demonstrated its usefulness in assessing the opposing roles of cortisol and DHEA in neurotoxicity, immunity and stress (Kamin & Kertes, 2017). When examining the cortisol:DHEA ratio a smaller ratio is indicative of a more balanced HPA axis (Heaney et al., 2012). The ratio has been investigated sparsely in healthy populations and within an exercising population, there is a dearth of research. A single study has investigated the ratio over the course of an exercise intervention in an older adult population (Heaney et al., 2013). The findings of Heaney and Colleagues (2013) demonstrated as theorised that the cortisol:DHEA ratio is highest pre-exercise and decreases immediately post-exercise and decreases further 1hr post-exercise.

1.1.2 Perceptual Post-exercise Recovery

Human perception has a rich research pedigree spanning multiple disciplines namely physics, biology, sociology, psychology and philosophy. As such, it needs a multidisciplinary approach to help with its understanding (Rossi & Berglund, 2011). Within sports science one of the first and now most widely used measures is that by (Borg, 1962) and the creation of the Rating of Perceived Exertion (RPE) scale. Borg (1990) highlights that the scale is used to measure an individual's perception of exertion which integrates information cued by the peripheral muscles and joints, cardiovascular functions and respiratory functions, and the central nervous system. The RPE scale initially was designed to grow linearly with work on a cycle ergometer with perception growing alongside exercise intensity and heart rate and therefore each perceptual rating was linked with a quantitative heart rate and bike load (Borg, 1990).

The original Borg-RPE Scale has then been simplified with the development of Borg's Category Ratio Scale (CR-10) RPE scale (Borg (1982)). This scale uses verbal indicators along the same ratio scaling as calculated from their quantitative meaning from the previous RPE scales but now with a categorical 0-10 scale. The key however with the CR-10 is it is anchored by the very well defined highest value (maximal) which helps to create "sameness" across individuals becoming a good reference point (Borg, 1990). Secondly, the CR-10 has been developed from a psychophysiological standpoint incorporating a categorical scale with ratio verbal markers, making it easy to understand and statistically analyse but also still links to physiological data such as heart rate and work (Borg & Kaijser, 2006). The CR-10 has become one of the most widely used scales and as such scales have been developed using the same scale to help with ease and familiarity amongst athletes, two such scales are the sessional RPE scale (Foster et al., 2001) and the Perceived Recovery Status (PRS) Scale (Laurent et al., 2011).

In more chronic and training settings RPE has also been used but as a sessional RPE to describe the perceived exertion over a training session. Foster et al. (2001) first developed sessional RPE again from the CR-10 scale. The scale was produced using the same 0-10 scale however the verbal markers were changed to reflect an answer to the question "How was your workout?", e.g. 0=Rest, 2=easy, 7=very hard and 10= maximal (Foster et al., 2001). This has then been used further by multiplying RPE by training hours to calculate a training load for each session (Foster et al., 2017). The sessional RPE scale again demonstrates the use of an adapted CR-10 to assess athletes' perceptions of exertion across a training session and then further over a training plan (Foster et al., 2017).

The PRS scale was developed by Laurent and Colleagues (2011) to create an easily accessible way to monitor athletes' perceived recovery. In the scale's development authors highlight that recovery includes physiological, psychological and emotional responses and therefore was aimed to create a scale that easily assessed these components. The creation of the PRS scale was based around the CR-10 for two main reasons. The first is that the CR-10 has linked to numerous physiological mediators consistently being shown as a good perceptual indicator of exercise tolerance (Green et al., 2007; Mihevic, 1981; Robertson & Noble, 1997). As such the PRS scale is aimed to be a parallel measure in perceptions but of percieved exercise recovery rather than exertion. The second is that from a practical and applied perspective a scale that is similar to the CR-10, which has been very widely used should hopefully make the PRS scale feel familiar and easy to use for athletes. The PRS scale has since been used across a range of sports and exercises as a measure of perceptual recovery (Cook & Beaven, 2013; Paul et al., 2019; Sikorski et al., 2013). The PRS scale has also been used in both acute settings such as the labratory or after a single performance (Paul et al., 2019; Sikorski et al., 2013) and longitudinal training settings (Sansone et al., 2020). The PRS scale is ultimately a broad easy to use scale design and used to assess perceived recovery of which the perceptions can be influenced by a whole range of physiological, psychological and emotional response components.

1.2 Physical Performance and Post-exercise Recovery

A simple marker of post-exercise recovery that is frequently used in the literature is the ability to perform effectively in a subsequent physical task. From an applied perspective if an individual can perform, have a period of recovery, and then perform again to at least to the same standard it could be said that the individual has recovered. Subsequent performance has been used as a marker by several researchers when assessing various physical recovery markers and recovery strategies (Bonnar et al., 2018; Cook & Beaven, 2013; McLellan et al., 2013; Ranalli et al., 2010). The possible limitation however with using subsequent performance as a marker of recovery is that there is no indication if in at least replicating a performance the body has had to ‘push’ further mentally and physically meaning the body needs more recovery or that it was able to achieve a replication despite not being fully recovered mentally and/or physically. A lack of full recovery may lead to overtraining and burnout (Gould & Dieffenbach, 2002). From an applied perspective subsequent performance may be seen as the best marker of recovery however when used in conjunction with hormonal markers such as cortisol and DHEA and perceptual markers subsequent performance is given greater meaning. Subsequent performance has greater meaning in conjunction, with other markers as it allows the researcher/coach to check that the subsequent performance by an athlete is not putting them at risk of burnout or overtraining as they are also able to see check the athletes' hormonal and perceptual recovery.

1.3 Personality

The role of personality has been widely researched throughout the social sciences. It has been of interest throughout history with one of the first being Aristotle who believed individuals had different virtues which are thought to have meant a set of stable characteristic traits (Pickhard, 2011). Sigmund Freud (1856-1939) is one of the key figures in the development of personality research as he introduced a psychodynamic approach to personality. Freud's psychodynamic approach focused on the id, the ego and the superego, with the ego balancing the impulsive id and the morals of the superego (Rennison, 2018). These components of personality all exist within a person and are proposed to create inner conflict; therefore psychodynamic approaches involve drawing attention to the motivation and energy that drive an individual's actions by considering their inner world (Kets de Vries & Cheak, 2014). The Psychodynamic approach was criticised in the 1960 and 70s with various other approaches being proposed, namely humanistic and behaviourist approachess (Wernicke-lichtheim et al., 2012). The humanistic approach focuses on the human as a whole and uses phenomenological and positive approaches to understand personality and development. Abraham Maslow believed that humans are essentially good and that when a certain set of needs are met individuals can thrive through self-actualisation. The behaviourist approach unlike most other personality approaches takes a vantage point of understanding an individual from the outside rather than the inside. Behaviourism approaches personality as simply the accumulation of everything an individual does. The ability to functionally analyse exactly how individuals behave as a function of their environment and map it out is the main aim of behaviourism (Funder, 2007). There are also approaches which are seen as more contemporary such as cognitive and trait approaches to personality (Gaines, 2019). The cognitive approach to personality combines personality theory with an individual's organisation of their mind and behaviour which is what is believed to manifest one's personality in social interactions (Brunas-Wagstaff, 1998).

A key theory on which further cognitive approaches to personality have been built is Kelly's (1955) personal construct theory. This construct emphasised the use of individuals' cognitive processes to emphasise the construction of the world. This concept of cognition has been incorporated into most psychological personality theories since (Endler, 2000). Trait approaches have their roots in classical times and over time a scientific approach has allowed cleaning up the number of traits and providing reliable and validated measures of these traits. Traits are seen as part of whom an individual is which influences their behaviour. The trait approach is one of the richest in nomological work within psychology(Funder, 2007). These approaches have led to some different definitions of personality. However, Mayer (2007) demonstrates how these definitions are generally very similar and that in essence describe personality as "a system of parts that is organized, develops, and is expressed in a person's actions. The system of parts includes such components as motives, emotions, mental models, and the self." (Mayer, 2007). Unsurprisingly personality has been investigated in many applied settings with researchers interested in how individual differences may affect the world around them in business, education, clinical and sport settings to name a few (Allen et al., 2013; De Raad & Schouwenburg, 1996; Doherty & Nugent, 2011; Matthews et al., 2005; Rauch & Frese, 2006). The majority of personality research in a sporting context has investigated the Big Five (extroversion, agreeableness, openness, conscientiousness, neuroticism) personality traits with a further focus mainly on performance (Barrick & Mount, 1991; Mount et al., 1998; O'Connor & Paunonen, 2007; Vedel, 2014; Zhao & Seibert, 2006). For example, Piedmont et al. (1999) found neuroticism (negatively) and conscientiousness (positively) to predict some variance in athletic performance. Mirzaei et al. (2013) agreed again finding conscientiousness positively predicted athletic performance, however, this was the only trait to be a predictor. However, from both a general (Feher & Vernon, 2021) and a sports performance viewpoint there is a call to move away from the broad trait-based approach which underpins the Big Five to concentrate on narrower and more specific personality variables that have a strong performance-focused theoretical basis (Roberts & Woodman, 2017). A theoretically based approach is probably also a wise one to take when looking at sporting recovery as this will help to better answer how, what and why individuals are recovering better not just that one trait is related to exercise recovery. With these considerations in mind, two personality traits of interest that may influence post-exercise recovery are alexithymia and optimism. The sections that follow will outline alexithymia and optimism as constructs and then explain their influence on post-exercise recovery.

1.4 Alexithymia

Alexithymia, a term coined by Sifneos (1972), from the Greek: a =lack, lexis = word, thymos = emotion, was very much born out of clinical psychology in the 1960s and 70s. Over the years it has often been tied to clinical work and health but more recently, especially since the construction of the Toronto Alexithymia Scale (TAS)-20 (Bagby et al., 1994), has been investigated at a non-clinical trait level. At a trait level alexithymia, measured by the TAS-20, is broken into three facets: Difficulty Identifying Feelings (DIF), Difficultly Describing Feelings (DDF) and Externally Orientated Thinking (EOT). It is not that individuals high in alexithymia do not have emotions and feelings it is that they struggle to work out what and then say how they are feeling (Taylor & Bagby, 2013). Alexithymia is commonly associated with areas of health and psychology often linked to, depression (Hintikka et al., 2001), PTSD (Frewen et al., 2008), Illness (Lumley et al., 1996; Porcelli & Taylor., 2018), and psychiatric disorders (Honkalampi et al., 2010; Pinna et al., 2020). In recent years however research has begun to investigate areas outside of health settings, for example in high-risk sport (Barlow et al., 2015; Woodman et al., 2009) and endurance running (Woodman & Welch, 2021). Alexithymic, and high in alexithymia are used throughout this thesis, this refers to individuals who score highly on the respective self-report measure (TAS-20) and are not a reference to clinical levels. Additionally, throughout this thesis alexithymia is conceptualised as a stable personality trait that does not change across time, and where an individuals' level of a particular trait can be placed on a continuum from very low to very high.

1.4.1 Alexithymia and Perceptions

Three main areas may help or hinder alexithymic individuals when they are perceiving recovery post-exercise, and these areas all generally revolve around how alexithymic individuals interact with stress. The areas are uncertainty, anxiety regulation, and somatisation. It is already known that individuals high in alexithymia perceived stress differently. These individuals often feel more stressed by life in general and stressors. High alexithymic' perceptions were comparatively over-reactive to minor stress and under-responsive to incremental stress (Kohn et al., 1994; Papciak et al., 1985). These findings have the potential to be linked to how alexithymia is related to anxiety and structure. Alexithymia has strong links to anxiety and anxiety disorders (Berardis et al., 2008; Berthoz et al., 1999) unsurprisingly due to alexithymics difficulties with emotions. An environment that can help to reduce anxiety is one with structures and plans (Buhr & Dugas, 2009; Czerniak & Haney, 1998). This is because structure and plans can help to reduce uncertainty (Huber et al., 1975), in turn reducing anxiety (Aberg et al., 2021; Witte, 1993). Intolerance of uncertainty has been found to predict 20% of the total variance of alexithymia (Tekel & Korkman, 2020). In addition, alexithymics need for certainty is demonstrated in the laboratory by Jacob (1998) who showed that alexithymics performed better on a memory task when elimination (creating more certainty) rather than focusing on the correct target was used. Exercise is known to have anxiolytic effects on individuals (Wipfli et al., 2008). It is also known that alexithymic individuals are drawn to activities with which they can regulate their anxiety as demonstrated by their draw to high-risk and extreme sports (Woodman et al., 2008, 2009). Anxiolytic effects have also recently been demonstrated through engagement in endurance running (Woodman & Welch, 2021) with marathons and ultramarathon runners benefiting from anxiolytic effects after running. Exercise performance has the ability to create anxiety through the need to protect the ego rather than protect one's life as seen in high-risk sport (Roberts & Woodman, 2015, 2017). If indeed alexithymic individuals are using sport to help regulate anxiety there is potential for them to become addicted and a need to continually push harder to get the same anxiolytic effect (Barlow et al., 2015). Initial evidence of an anxiolytic effect of exercise is demonstrated in the work by Woodman & Welch (2021) finding both marathons and ultramarathons were anxiolytic for alexithymic individuals. It is known that using high-risk sports only has a temporary effect on regulating anxiety (Woodman et al., 2008) and as such if exercise is the same it may affect the perception of anxiety by alexithymic individuals. Theoretically, a reduction and then increase of anxiety could affect perceptions of post-exercise recovery in that the immediate anxiolytic effect may lead alexithymic individuals to perceive greater recovery from exercise however once the anxiolytic effect 'wears off' it will potentially have a negative effect on the perception of recovery with individuals feeling less recovered due to anxiety increasing again. Alexithymics have been linked to exercise addiction as well as the motivation behind it often being habitual (Manfredi & Gambarini, 2015). Alexithymia may mean individuals are drawn to completing the exercise even though they are not recovered and as such have a further negative effect on perceptions of recovery and physical recovery.

After exercise individuals often experience aches and pains. As already highlighted alexithymic individuals often perceive themselves as more stressed (Terock et al., 2020) and struggle with life's daily hassles (Kohn et al., 1994). Alexithymic individuals also struggle with identifying and describing emotions so it is unsurprising that it has ties to somatisation (De Gucht & Heiser, 2003). Somatisation is the experience of psychological difficulties through physiological sensations (Lipowski, 1987). The most common example of somatisation is a panic attack often brought on by psychological anxiety but appears physiologically as shortness of breath, raised heart rate and sweating. It is, therefore, possible that the physical aches and pains may be particularly strong or further exaggerated by alexithymic individuals when recovering from exercise is they are already psychologically stressed. Hence the potential for somatisation may lead to the perception of recovery being driven more by physiological feeling than psychological emotion.

Under the assumption that exercise will be stressful, and that performance creates anxiety and uncertainty there is theoretical reasoning that alexithymics will perceive exercise and performance, and how they recover from it, differently to individuals lower in alexithymia. The relationship between alexithymia and post-exercise recovery may have added complications due to the anxiolytic effect of exercise. However, other than immediately post-exercise, it is still expected alexithymia will have a negative effect on post-exercise recovery. The addition of somatisation adds further rationale for alexithymics perceiving they are less recovered.

1.4.2 Alexithymia and Cortiosl and DHEA Responses

Alexithymia and its influence on the HPA axis have been investigated scientifically, however, the research has focused on using the TSST with seemingly no literature covering the relationship between alexithymia and the HPA axis response in a physical exercise setting. When looking at alexithymia's relationship with the HPA axis, research has presently been limited to investigating cortisol. In addition, some researchers only find significant results when investigating one facet of three alexithymia facets DDF, DIF, and EOT. Timary et al. (2008) using the TSST reported that participants scoring high on alexithymia evidenced an increased basal anticipatory cortisol concentration but for individuals high in alexithymia peak cortisol and area under the curve when recovering were no different to individuals low in alexithymia. Multiple regression analyses revealed that the increased cortisol in high alexithymia scorers was due to DDF high scorers reacting with a large increase in cortisol during anticipation but not during exposure to the stress test. Hua et al. (2014), using the TSST found that participants scoring high on alexithymia reacted significantly more intensely than individuals low in alexithymia in basal anticipatory as well as peak cortisol and area under the curve for the recovery period. Regression analyses revealed that the increased HPA axis activity was related to only one alexithymia facet, DDF, and distinguishing them from bodily sensations and emotional arousal. McCaslin et al. (2006) using a video challenge reported no relationship between alexithymia and cortisol in response to psychological stress in police academy recruits. Alexithymia appears to have a positive relationship with cortisol in anticipation events and sometimes but not always have a higher peak during the stressor. The two studies which used the TSST found differing results on the underlying facet causing an increase in cortisol one DIF and one DDF however their overall alexithymia score still showed an increase in Cortisol.

In chronic settings, research into the relationships between alexithymic and chronic hormonal markers is sparser still. Individuals high in alexithymia have been shown to have lower cortisol awakening response (CAR) than those low in alexithymia (Härtwig et al., 2013). Within hair cortisol research amongst pregnant women, women high in alexithymia had higher concentrations of hair cortisol compared to those lower in alexithymia (Kajanoja et al., 2020). Hartwig's (2013) CAR research suggests that individuals high in alexithymia have chronically lower cortisol concentrations due to lower CAR. In contrast, Kajanoja's (2020) hair cortisol research demonstrated that individuals higher in alexithymia have chronically greater cortisol concentrations. These contrasting findings make it difficult to predict the potential chronic effects of alexithymia on cortisol in a post-exercise recovery setting. Whereas in an acute setting it would be expected that in anticipation of an exercise stressor alexithymic individuals will have higher cortisol concentrations and they may well also have higher concentrations immediately after exercise (a stressor).

1.4.3 Alexithymia and Physical Performance

Within sport alexithymia has predominately been investigated within high-risk sports investigating engagement with high-risk sports and effects on anxiety when participating in these sports (Barlow et al., 2015; Woodman et al., 2009). There is however theoretical rationale as to why alexithymics should perform well in sporting contexts (Roberts & Woodman, 2017), along with anecdotal evidence (Lopes et al., 2019) which found greater numbers of alexithymic athletes competing within a student population. As already highlighted alexithymic individuals may use sport to reduce anxiety due to sports anxiolytic effects. Alexithymia does also have links with self-harm (Norman et al., 2020; Norman & Borrill, 2015). Alexithymics may manifest the build-up of emotion as pain and/or injury and therefore the pain may be helping to relieve the build-up of psychological distress (Lumley, 2004). This may also be achieved by punishing oneself through sport and therefore theoretically alexithymics may not mind and even enjoy pushing their body and as such pushing it to achieve a subsequent performance may not be difficult for alexithymic individuals.

1.5 Optimism

First coined in the 1700s optimism is born out of Latin Optimus (the best) being described in the doctrine as "best of all possible worlds". Contemporary research lies alongside Scheier's (1994) creation of the Life Orientation Test-Revised (LOT-R). A self-report measure of optimism which allows investigation into the correlates between optimism and various parts of life. Optimism is often used in a very diverse way in many different contexts. Optimistic and high in optimism are also used throughout this thesis this refers to individuals who score highly on the respective self-report measure (LOT-R), this is a dispositional optimism measure investigating optimism as a stable trait. Additionally, throughout this thesis Dispositional optimism is conceptualised as a stable personality trait that does not change across time, and where an individuals level of a particular trait can be placed on a continuum from very low to very high. Optimism is generally correlated and investigated with positive outcomes (Scheier & Carver, 1987), better health (Scheier & Carver, 2018;

Steptoe et al., 2006), increased effort (Nes & Segerstrom, 2006), low stress (Banerjee, 2012; Chang, 1998), and greater engagement (Geers et al., 2009). These relationships lead to optimism generally being portrayed as a ‘lighter’ trait; however, it does also have a darker side being linked to worse results in gambling (Gibson & Sanbonmatsu, 2004), and entrepreneurial activity (Amore et al., 2020). This darker side is generally driven by optimistic individuals expectations of things improving and the future being better causing these individuals to continue when it may be better to quit (Amore et al., 2020; Gibson & Sanbonmatsu, 2004).

1.5.1 Optimism and Perceptions

Four main areas may help or hinder optimistic individuals when they are perceiving recovery post-exercise, and these areas all generally revolve around how optimistic individuals interact with stress and performance. These areas are lower stress perception, better general health, a goal-orientated approach, and coping. Optimists by nature generally expect positive outcomes in the future and therefore it would be anticipated that they will expect to be better recovered in the future (Carver & Scheier, 2014). Optimistic individuals also perceive they are less stressed. For example, optimistic individuals under conditions of experimental laboratory stress were reported to perceive less stress and higher control despite no physiological difference in cortisol response (Endrighi et al., 2011).

Optimism also has a strong relationship with well-being and health-protecting behaviours. Carver and Scheier in their 1992 review describe the empirical and theoretical evidence of optimism and its relationship with both physiological and psychological health. Optimism is found to benefit health both psychologically and physically. Optimism is linked with better psychological health (Achat et al., 2000), lower depression (Vickers & Vogeltanz, 2000), stress (Banerjee, 2012; Chang, 1998), better-coping styles (Nes & Segerstrom, 2006) and quicker recovery after surgery (He et al., 2016; Scheier et al., 1990). Furthermore, optimism is linked with improved health physically; reduced risks of physical health conditions and/or quick recovery from physical conditions such as coronary surgery (Ronaldson et al., 2015; Scheier & Carver, 1987, 2018; Scheier et al., 1999). A potential reason behind optimisms links to better health is its link to health-protecting behaviours. For example, optimism is associated with the use of more positive coping styles and good goal attainment.

Hanssen et al. (2015) demonstrate how Optimists ability to both tenaciously follow goals but also flexibly adjust them mediates the links between optimism and depression, well-being and anxiety in all cases creating a positive outcome e.g. lower depression and anxiety and better well-being. In addition, optimism also predicts less acute and chronic pain (Basten-Günther et al., 2018). Optimisms links to low pain and health-protecting behaviours lay theoretically driven grounding for Optimists perceiving they are more recovered after exercise as they have less pain, engage in health-protecting behaviours and use appropriate coping.

Optimists are known for engaging with approach coping. Nes & Segerstrom (2006) conducted a meta-analysis into optimism and coping with their findings showing that dispositional optimism was positively associated with approach coping strategies to eliminate, reduce, or manage stressors or emotions. In addition, they found that optimism were able to adjust their style of coping effectively depending on the stressor and the most appropriate type of coping. When taken in a recovery setting the use of better coping styles means that theoretically Optimists will engage with approach coping in a recovery setting and aim to eliminate, reduce and manage the stressors and emotions associated with recovery and therefore perceive better recovery.

Optimists overall expectancy of positive outcome and engagement with approach coping may be expected to lead to positive perceptions of recovery. When combined with optimisms' associations with lower stress levels, better well-being and engagement with positive health behaviours again further rationale is added for positive perceived recovery by Optimists.

1.5.2 Optimism and Cortisol and DHEA

Optimism and the HPA axis have been investigated in several studies, most of which have used the TSST. However, findings are somewhat conflicting, Nes et al. (2005) reported that optimistic beliefs in combination with high self-awareness increased persistence as well as indicators of the sympathetic nervous system (Skin conductance & Heart Rate) and HPA activity (salivary cortisol) following a stressor. The mechanism underlying an increase in HPA axis activity is proposed to be engagement (Carver & Scheier, 1998). Optimists are likely to see positive outcomes as attainable, they may be more inclined to engage in continued effort to achieve their goals (Carver & Scheier, 1998), especially when self-consciousness focuses individuals on their goal-directed behaviour and increases the effects of self-regulation (Scheier & Carver, 1988). However, in contrast, Endrighi et al. (2011) reported no associations between optimism and stress-induced cortisol changes in a laboratory stress test; however, perceived stress was significantly lower, and perception of control was significantly higher in more optimistic participants during a psychophysiological stress testing session. Puig-Perez et al. (2015) found that Optimists showed faster cortisol recovery (quicker reduction in cortisol concentration) post TSST than individuals low in optimism. Although the literature on acute recovery from a stressor is mixed for cortisol, DHEA has not been investigated. Increased engagement, increases cortisol as theoretically presented by Nes & Segerstrom (2006). Positive affect is mostly associated with decreased or no change in cortisol although there is an exception where greater engagement or excitement leads to an increase in cortisol (Cohen & Pressman, 2006).

Within chronic settings, there is less research investigating the relationship between optimism and the HPA axis. However, optimism has been found to be negatively associated with CAR (Endrighi et al., 2011). Likewise, optimism and hair cortisol has received very little research, though one study has investigated the relationship between dispositional optimism and hair cortisol concentration in adolescence with dispositional optimism negatively related to hair cortisol concentration (Milam et al., 2014).

1.5.3 Optimism and Performance

Optimism has a wealth of research in relation to performance. In terms of sporting performance Ortín-Montero et al. (2018) review of optimism in sport shows a positive relationship between optimism and sporting performance. This review does, however, note the lack of quality within these studies due to poor and non-specific measures of performance with a lack of homogeneous approaches measuring performance by the studies investigated in the review. There is however still a good rationale for optimism predicting better performance as highlighted by Roberts & Woodman (2015). This framework is built around optimism, coping strategies, performance under pressure and effort. With its relationship to task-focused coping, better engagement, and favourable expectancy of the future, theoretically, it could also be expected that optimism will lead to better performance on subsequent tasks that follow an initial performance-driven activity. Previous research has demonstrated the Optimists use of effective coping strategies is in part at least a factor to Optimists performing better (Roberts & Woodman, 2015). It is then further noted that in attentional control theory increased anxiety (expected with performance) can be beneficial to ones' performance providing confidence is high as individuals increase effort in the task. As such Roberts & Woodman (2015) suggest under pressure Optimists are likely to increase effort which will, in turn, lead to a good performance. Task-focused coping would be expected to help Optimists on subsequent performance bouts in a performance setting, and it has been demonstrated in sporting contexts that Optimists have a positive relationship with task-focus coping and emotion-focused coping using the most appropriate coping dependent on the stressor (Nes & Segerstrom, 2006). If Optimists use clearer thinking and do not disengage with the subsequent performance due to being tired or being anxious, it may lead to an expectation that there will be a benefit to subsequent performance especially when task-focused coping is used by Optimists. Optimism has also been shown to have a positive relationship with goal engagement (Geers et al., 2009; Geers, Wellman, Fowler, et al., 2010) and as such if the ability to recover performance during successive sport-related tasks is perceived as a goal it would be expected that high optimism scores will be related to better subsequent performance in such a scenario. The findings of Geers et al. (2009), are of note here who found the relationship between optimism and goal engagement is moderated by goal priority such that the higher priority the goal the greater the engagement of those high in optimism. In an exercise recovery setting, this would mean providing recovery is a high priority for Optimists, optimists would engage with recovery well. Goal engagement has been demonstrated in a sporting context with persistence at engaging with aerobic exercise training used as the modality to explore goal priorities moderation of the optimism and engagement relationship. Finally, a general positive expectancy of the future is likely to benefit performance, as Optimists focus on near misses rather than failure (Aspinwall & Richter, 1999). When gambling Optimists are not afraid to move on from unsolvable problems to allocate more effort to a task they believe is not impossible (Aspinwall & Richter, 1999; Gibson & Sanbonmatsu, 2004). Previous research into positive expectations means that a bad first performance will not be expected to negatively affect a subsequent performance.

1.6 Alexithymia, Optimism and Recovery

Both alexithymia and optimism have theoretical reasoning for influencing post-exercise recovery. Existing literature shows that alexithymia can influence the HPA axis in stressful situations with several studies investigating HPA axis stress by using the Trier Social Stress Test (TSST). These findings among research into cortisol are mixed for alexithymia with some showing a blunted response to stress via suppressed cortisol concentrations (Härtwig et al., 2013) and others an increased response to the stress via increased cortisol concentrations (Timary et al., 2008). Alexithymia also by its very nature influences perceptions due to having difficulty identifying and describing emotions (Bagby et al., 1994) and emotion regulation and knowledge (Luminet & Zamariola, 2018). Individuals high in alexithymia have difficulty with describing emotions as demonstrated in a sporting context whereas individuals high in alexithymia describe habit as their reason for exercising (Manfredi & Gambarini, 2015).

Optimism has also been shown to influence the HPA axis in stressful situations again investigated mainly through the TSST. Again optimism and cortisol has been investigated through the TSST and show mixed results. Some evidence demonstrates Optimists sometimes have elevated cortisol concentrations, and other research shows Optimists have suppressed cortisol concentration (Endrighi et al., 2011; Nes et al., 2005; Salzmann et al., 2018). Optimism is also likely to influence individuals' perceptions as these individuals tend to show positive bias and positive framing of situations. Optimists positive framing of situations is demonstrated in the findings by Aspinwall & Richter (1999) who examined optimisms relationship with the persistence and performance on unsolvable and solvable anagrams. Initially, there were seven unsolvable anagrams which were followed by 14 solvable anagrams, Optimists disengaged from unsolvable anagrams on average nearly four minutes sooner than low optimists. Additionally, those high in optimism solved the solvable anagrams faster. This research demonstrates Optimists' ability to allocate effort effectively into the solvable anagrams and that not being able to solve an anagram did not deter them from applying further effort. Optimists focus on the potential to win/complete rather than focus on previous losses is further examined and demonstrated by Gibson & Sanbonmatsu (2004) in a gambling setting. They demonstrated that Optimists continue to expect to win even after losing and focus more on their previous near wins rather than losses when placing bets/continuing to bet. With both traits influencing perceptions and hormones independently before adding exercise it may be expected that in a post-exercise recovery setting these influences may also be seen or potentially become even stronger. The influence of each trait will be dependent on how an individual's mind and body deal with exercise as a stressor in comparison to the previous stressors investigated such as a TSST.

1.7 Summary

In summary, it is known that exercise causes acute disruptions to various processes within the body. Hence, emphasising the need for adequate post-exercise recovery during the period that follows such activity. Post-excise recovery can be measured using perceptual and physiological markers to determine how an individual is recovering during the post-exercise period. Alexithymia and optimism, are known to influence certain hormonal and perceptual responses outside of a post-exercise recovery setting. However, the specific influence of alexithymia and optimism on markers of post-exercise recovery is currently unknown. With this in mind, the novel aim of this thesis was to investigate the independent influence that alexithymia and optimism may have on certain markers of post-exercise recovery across several different exercise settings.

1.8 General Thesis Aims

Chapter 2: The primary aim of Chapter 2 was to investigate the influence of Alexithymia and Optimism on acute post-exercise recovery in between two treadmill running bouts, a secondary aim was to investigate this influence after the second treadmill running bout.

Chapter 3: The primary aim of Chapter 3 was to investigate the influence of Alexithymia and Optimism on chronic exercise recovery over a three-month training period, as assessed by hair cortisol concentrations and perceptual recovery, within a regularly training sporting student population. The secondary aim was to investigate the influence of Alexithymia and Optimism on chronic perceptions of well-being and stress.

Chapter 4: The primary aim of Chapter 4 was to examine the influence of Alexithymia and Optimism on post-exercise recovery during the build-up to, and in the period immediately after, an amateur cycling race.

2 The influence of Alexithymia and Optimism separately on perceptual, hormonal and subsequent performance markers of post-exercise recovery in an acute laboratory setting.

2.1 Introduction

Performing at one's optimum level brings a host of rewards. In many cases, these rewards come as a result of athletes performing at their best over numerous occasions. For example, swimmers often compete in heats and finals on the same day, multi-event athletes compete over numerous days, and many athletes train more than once a day in preparation for competition. One factor that underpins an athlete's ability to produce repeat performances of the highest level is effective post-exercise recovery (Lau et al., 2001; Monedero & Donne, 2000). Specifically, if an individual is not sufficiently recovered after exercise, they will likely not be able to perform as well during subsequent bouts of exercise (Rowlands et al., 2008; Skorski et al., 2019).

Exercise is known to cause acute physiological imbalances (Hackney, 2006; Sothmann et al., 1996) hence, there is then a need to recover these imbalances after exercise for the body to return to homeostasis. Repeated performance bouts or training sessions may not allow the body to recover and regain full homeostasis in sufficient time after a first exercise session before performing a second exercise session if post-exercise recovery is insufficient (Hackney & Viru, 1999; Ronsen et al., 2002).

A better understanding of the factors that may influence how one acutely recovers from exercise is therefore important both scientifically and practically. Moreover, investigating some of the personal factors that may determine this is of equal importance Lee et al. (2017) propose that physiological status during post-exercise recovery could be investigated through the endocrine response using biomarkers such as cortisol and Dehydroepiandrosterone (DHEA), which are part of the Hypothalamic Pituitary Adrenal-Axis (HPA axis). The use of HPA axis biomarkers allows investigation of the response of the neuroendocrine system to acute exercise and recovery from that exercise (Hill et al., 2008; Luger et al., 1987; Stranahan et al., 2008).

Activation of the HPA axis in a sporting context depends on exercise duration and intensity (Hill et al., 2008; Luger et al., 1987; VanBruggen et al., 2011), it is generally accepted that 30 minutes of exercise above 80% $\dot{V}O_2$max will activate the release of cortisol (Hill et al., 2008; Luger et al., 1987; VanBruggen et al., 2011). When investigating post-exercise recovery an investigation of the ratio which takes into account both cortisol and DHEA is of importance as it gives a better indication of the return to homeostasis of the endocrine system post-exercise than the sole use of either marker (Kamin & Kertes, 2017). In a small sample of studies, it has been demonstrated that both cortisol and DHEA will increase during running exercise (Heaney et al., 2013; VanBruggen et al., 2011). The shift from cortisol to DHEA in an exercise setting has not been investigated. There has been an investigation of an acute stressor (skydiving) on both hormones, which demonstrated a shift from cortisol to greater secretion of DHEA during and after the stressor (Oberbeck et al., 1998). As exercise is a stressor the same shift would be expected post-exercise as seen in the skydiving. Post-exercise cortisol generally increases immediately after exercise with a peak at 10-20 minutes post-exercise before then declining (Rojas Vega et al., 2006; Shinkai et al., 1996). Following a second bout of exercise in relatively quick succession, there is also an expectation that cortisol will be even higher at the end of the second bout than the first (Ronsen et al., 2002).

Although DHEA has not been investigated in isolation during the post-exercise recovery period several studies have investigated DHEA in conjunction with cortisol after exercise (Chatard et al., 2002; Heaney et al., 2013). Heaney et al. (2013) investigated both cortisol and DHEA in post-exercise recovery from an incremental submaximal treadmill test, in an acute post-exercise setting. Heaney found there was an increase in cortisol but not DHEA just prior to exercise. Immediately after exercise DHEA was significantly greater than just before the exercise whereas cortisol was significantly lower. At one-hour post-exercise DHEA returned to similar concentrations to just before exercise whereas cortisol was significantly reduced in comparison to before the exercise. When Heaney and colleagues (2013) investigated the cortisol:DHEA ratio in the same study there was a significant reduction in the ratio both immediately and one hour after the exercise in comparison to just prior to the exercise. This decrease in the ratio represents a more favourable endocrine profile with a greater balance between cortisol and DHEA.

Along with the known physiological disturbances, post-exercise recovery is also linked to disturbances in various emotions, feelings, and moods which in turn influence individuals' perceptions of recovery, (Bernstein et al., 2019; Bernstein & McNally, 2018; Ekkekakis, 2008; Ekkekakis & Dafermos, 2012; Kenttä et al., 2006). Perception of post-exercise recovery has been investigated in a multitude of ways (Kellmann, 2011; Kenttä & Hassmén, 1998) however the introduction of the Perceived Recovery Status (PRS) scale by Laurent and colleagues (2011) provides a simple perceptual measure of recovery that can be used in acute exercise settings. Perceived recovery is linked to better subsequent exercise performance (Cook & Beaven, 2013; Laurent et al., 2011) and a better physiological state (Stanley et al., 2012). This suggests that an individual's perceived recovery can be used as an indicator of their ability to adequately perform again, and their general physiological recovery.

While there is a good understanding within the literature about the way that recovery markers such as those above may be transiently modified during the acute post-exercise recovery period, some of the reasons for why individuals recover differently physiologically and perceptually following exercise (Kellmann et al., 2018; Skorski et al., 2019), even during passive recovery (Dupont et al., 2004), warrant further investigation. One potential reason for this that has surprisingly not been investigated within the post-exercise recovery domain is personality differences amongst individuals. This is particularly surprising given that some of the aforementioned markers that are used to assess post-exercise recovery may also independently differ as a result of an individuals' personality (Carver & Scheier, 2014; Härtwig et al., 2013; Lai et al., 2005; Luminet & Zamariola, 2018).

One trait with the potential to affect post-exercise recovery in an acute setting is Alexithymia.[1] Alexithymia has been described as the absence of words to express emotions (Roberts & Woodman, 2015). In terms of being able to interpret, describe and regulate emotion alexithymic individuals struggle due to alexithymia being associated with poor emotion regulation (Luminet & Zamariola, 2018) This has recently been supported through neuroscience with emerging structural and functional evidence (Fang et al., 2018; Goerlich-Dobre et al., 2015; Laricchiuta et al.,

[1] Alexithymic, and high in alexithymia are used throughout this chapter, this refers to individuals who score highly on the respective self-report measure (TAS-20) and are not reference to clinical levels. Additionally, throughout this chapter we conceptualised alexithymia as a stable personality trait that does not change across time, and where an individuals' level of a particular trait can be placed on a continuum from very low to very high.

2015). Alexithymia is also generally associated with poorer health and well-being (Kojima, 2012; Lumley et al., 2008, 1996; Ricciardi et al., 2015), somatisation (De Gucht & Heiser, 2003), high risk sport (Barlow et al., 2015; Cazenave et al., 2007; Woodman et al., 2008, 2009), anxiety (Berardis et al., 2008; Hendryx et al., 1991), depression (Hintikka et al., 2001; Honkalampi et al., 2018) and autism (Kinnaird et al., 2019; Poquérusse et al., 2018).

A second trait with the potential to affect post-exercise recovery in an acute setting is Dispositional Optimism[2] which has been described as a disposition to have positive expectancies towards the future (Carver & Scheier, 2014). Optimism is often linked positively to emotion regulation and having a good understanding of one's emotions (Jenaabadi et al., 2015). The majority of optimism research has its foundations in self-report data, however, as with alexithymia, self-report findings are recently supported by neuroscientific findings both structurally and functionally (Han et al., 2018; Yang et al., 2013). Optimism is generally associated with better well-being, better physical health, good mental health, greater engagement, higher income, low levels of avoidance, increased effort due to confidence and self-efficacy (for review Carver & Scheier, 2014).

Alexithymia's relationship with the HPA axis has been investigated extensively in clinical populations and on a more chronic level (Cascino et al., 2020; Guilbaud et al., n.d.; Härtwig et al., 2013). Coverage of the acute stress response in the general population, however, is reasonably sparse. Moreover, there is seemingly no known investigation between alexithymia and HPA axis recovery following an exercise-type stressor. Researchers however have mainly used the trier social stress test (TSST) to investigate HPA axis recovery from psychological stress (Kirschbaum et al., 1993). The TSST is known to increase the cortisol response between two to threefold with it peaking 10-20mins after the end of the task (Kudielka & Wüst, 2010). From a cortisol perspective, there is some evidence a greater increase in cortisol during a recovery phase the more alexithymic an individual, in line with previous literature (Hua et al., 2014; Timary et al., 2008). It should be noted these studies disagreed on the underlying facet of alexithymia causing this increase in cortisol, Difficulty

[2] Optimistic and high in optimism are also used throughout this chapter this refers to individuals who score highly on the respective self-report measure (LOT-R), this is a dispositional optimism measure investigating optimism as a stable trait. Additionally, throughout this chapter we conceptualised optimism as a stable personality trait that does not change across time, and where an individuals' level of a particular trait can be placed on a continuum from very low to very high.

Identifying Feelings (DIF) was the facet causing the increase in one case (Hua et al., 2014) and Difficulty Describing Feelings (DDF) the other facet responsible for the increase in the other study (Timary et al., 2008). For overall alexithymia, however, an increase was still seen so the underlying factor may not be important. DHEA is less understood due to the lack of previous literature however due to DHEA's link with cortisol and the transfer from cortisol to DHEA during and after a stressor seen in previous literature (Oberbeck et al., 1998).

There has been slightly more research regarding optimism and recovery from a stressor, specifically with HPA axis biomarkers, and primarily measuring cortisol. This however is again in relation to psychological stressors rather than physical exercise. The results of investigations into cortisol and optimism in the recovery period after the TSST, or a similar laboratory stressor, are mixed. This may be in part due to different ways of measuring cortisol throughout the recovery period. Nes et al. (2005) found optimism resulted in a smaller decline (flatter slope) in comparison to the general sharper declining cortisol slope over the 45-minute recovery period from their stressor however this was only when self-consciousness was also included in the model when self-consciousness was not included optimism did not influence the cortisol slope. Puig-Perez et al. (2015) and Brydon et al. (2009) found an inverse relationship between optimism and post-task cortisol demonstrating that optimists had a quicker cortisol recovery. Endrighi et al. (2011) found no relationship between optimism and cortisol post-stressor.

There are good rationales to explain both an increase or a decrease in cortisol post-stressor for optimists'. The rationale behind an increase is due to optimists extra engagement and effort during a task which leads to heightened cortisol, this was proposed by Nes et al. (2005) and is proposed to explain why the increase in cortisol was only found when participants with high levels of public self-confidence and in combination these predicted task persistence. This is derived from the engagement model that optimists' greater goal engagement is beneficial in the long-term, but short-term there may be physiological costs (Cohen et al., 2000; Maier et al., 2003; Mullen & Suls, 1982; Segerstrom et al., 2003; Waldstein et al., 1997).

The negative relationship between optimism and cortisol has the potential to be explained by the strong link with positive affect. Positive affect is mostly associated with decreases or limited changes in cortisol (review Cohen & Pressman (2006)). The excitement/arousal part of positive affect which one may expect to interplay when undertaking exercise, as these will cause increases in cortisol levels. This potential short rise in cortisol may be seen when recovering from exercise however due to optimism links to less intense and often health-protecting stress response (Carver & Scheier, 2014) it would be expected that the cortisol:DHEA ratio will be indicative of a healthier endocrine response and recover more quickly.

Personality is also known to influence the way that individuals perceive the world around them (Blake & Ramsey, 1951). For example, personality influences the interpretation of emotions (Feist & Feist, 2006). Furthermore, ongoing perceptions of emotion, coupled with a situation/s arguably underpin a large part of individual behaviour (Dolan, 2002). The link between emotions, perception and the environment with behaviour and the influence of personality on these provides a rationale for personality altering perceptions of recovery with potential interaction from the environment.

Perceived recovery can be measured using the PRS Scale (Laurent et al., 2011). Laurent and Colleges (2011) created this scale as a simple non-invasive measure that considers the physiological, psychological and emotional response components of exercise recovery. The scale follows a similar format to the Rating of Perceived Exertion Category Rating 10 (CR-10) scale (Borg, 1982) so that there is familiarity for athletes when using the scale. The PRS scale was also based around the CR-10 scale (Borg, 1982) due to the successful psychobiological assessment of exercise that the CR-10 has previously shown which the creators hoped would also, therefore, feature in the PRS scale (Laurent et al., 2011).

It is important to note that although both optimistic and alexithymic individuals do have feelings and emotions, alexithymic individuals struggle with the interpretation of these feelings often finding it easier to describe the physical sensations rather than describe the potentially more cognitive side to emotion (Luminet & Zamariola, 2018) whereas optimists tend to regulate emotions well and most of the time will regulate into a positive mindset (Yang et al., 2013).

Perceived recovery of alexithymic individuals may arguably be influenced by anxiety regulation, somatisation and the structure of the environment around them. There is a theoretical rationale that individuals high in alexithymia may use sporting performance to regulate anxiety (Roberts & Woodman, 2015, 2017). Sporting performance may allow alexithymic individuals to regulate anxiety as there is a risk to the ego. The risk to ego is created because performance can go well or not, the risk of a bad performance, therefore, threatens the ego. This risk/threat to the ego of a poor performance increases anxiety before performing which will then decrease during the performance (Fenichel, 1939; Roberts & Woodman, 2015, 2017). Partaking in sport is also anxiolytic before adding the influences of alexithymia (Asmundson et al., 2013). The reduction in anxiety immediately after exercise will lead to individuals feeling more positive (Asmundson et al., 2013) and therefore potentially individuals will give a higher (more recovered) PRS.

A second variable that may help to reduce anxiety and stress and therefore have a beneficial effect on PRS for alexithymics is the structure and plan of exercise. Plans and certainty are known to help individuals reduce anxiety and stress (Buhr & Dugas, 2009; Huber et al., 1975). This may be particularly true for individuals high in alexithymia as alexithymic individuals are known to not cope with uncertainty and it causes them stress (Ozsivadjian et al., 2020). Therefore in a recovery setting if the recovery period is planned and well structured this may have a positive influence on perceived recovery, particularly for alexithymic individuals. The reverse of this means that if a recovery period is not well planned or structured then anxiety is likely to be higher, especially for alexithymics who have particular difficulties with uncertainty, and therefore a negative effect on perceived recovery may occur. Finally, somatisation may also influence perceived recovery in individuals high in alexithymia due to the strong link between somatisation and alexithymia (De Gucht & Heiser, 2003). Somatisation is the physiological representation of psychological problems/strain (Lipowski, 1987). From a recovery perspective therefore the perceived recovery of alexithymic individuals is likely to be driven from physical feelings and potentially less by psychological ones as psychological feelings may manifest as physiological pain, aches or soreness after exercise.

Optimistic individuals PRS may be influenced by the priority they place on sporting performance and therefore the effort and engagement in that performance. Roberts & Woodman (2015) propose that theoretically, optimism should have a beneficial effect on performance due to an increase in effort by optimistic individuals to achieve their goal/s. It has also been demonstrated that optimists engage more effort with goals on which they place a high priority (Geers et al., 2009). This engagement with priority goals has the potential to affect PRS in two ways. Firstly, providing the exercise is of high priority and optimists do engage more effort they may therefore need to recover more due to the increased effort and therefore this would have a negative effect on PRS. If recovery itself is also a high priority for optimistic individuals however they may engage more effort in their recovery and this would then have a positive effect on PRS. Optimists are also known to generally be optimistic about the future (Carver & Scheier, 2014) and therefore if this positivity follows in recovery this would have a positive effect on PRS for optimistic individuals. This is demonstrated well in optimism and placebo literature where optimism has a positive relationship with the positive placebo response as they expect the placebo to work (review Kern et al., 2020). When applying this to post-exercise recovery providing optimists expect themselves to recover across the recovery period this should have a positive effect on perceived recovery with optimists perceiving greater recovery. A final element to add is optimism relationship with pain. Basten-Günther et al. (2018) systematic review of optimism and the experience of pain provides evidence that optimism is overall negatively related to both acute and chronic pain. A possible mechanism behind this is that optimists have a lower pain sensitivity (Goodin & Bulls, 2013). Whilst recovery is not the absence of pain, it is likely lower feeling of pain will have a positive impact on perceived recovery, therefore if optimists experience less pain this is likely to have a positive influence on perceived recovery, so optimists may perceive they are more recovered. Although there is an argument for optimists perceiving poorer recovery overall their general disposition to expect a better future if applied across a recovery period leads to the thought optimists will perceive they are more recovered especially because of the negative relationship between optimism and pain.

Considering how alexithymia and optimism may independently affect certain markers that may be associated with post-exercise recovery for instance, the HPA axis, perceptions, and performance on subsequent tasks. This novel study aimed to investigate the unknown effects of alexithymia and optimism traits on acute post-exercise recovery following high intensity endurance exercise. Specifically, the study investigated how alexithymia and optimism influenced how individuals recovered hormonally and perceptually in between two pre-loaded 3km running time trial performances (3kTT), approximately one hour apart, and during the 30 minute period following the second pre-loaded 3kTT. Performance on the second pre-loaded 3kTT was used as a further marker of recovery. To highlight the way that these personality traits may influence one's ability to physically perform again soon after a prior bout of intense physical activity, (Greenwood et al., 2008; Monedero & Donne, 2000; Thiriet et al., 1993; Weltman et al., 1979). Specifically, because alexithymia and optimism both have positive links to better performance however this is over a single bout (Lopes et al., 2019; Ortín-Montero et al., 2018). It is however unknown if each traits single performance results will map onto a subsequent performance bout. Subsequent exercise performance may be seen as an all-encompassing marker of recovery, however, the recovery and performance in sports consensus statement by Kellmann et al. (2018) highlights the need for a multidisciplinary individualised approach to recovery and potentially more finite detail.

The primary aim of the current study was to investigate the effect of alexithymia and optimism on acute post-exercise recovery between two treadmill running bouts, a secondary aim was to investigate this effect after the second exercise bout. The first hypothesis for this study was that individuals higher in alexithymia would recover better from acute treadmill running, with recovery measured by subsequent performance on the second 3kTT, perceived recovery and endocrine response. The second hypothesis for this study was that a positive relationship would exist between dispositional optimism and post-exercise recovery again with recovery measured by subsequent performance on the second 3kTT, perceived recovery and endocrine response. In all hypotheses, a negative relationship between the personality trait and subsequent performance on the second 3kTT indicates a better recovery. A positive relationship between the personality trait and perceived recovery indicates better recovery. Finally, a smaller area under the curve for the cortisol:DHEA ratio indicates better recovery. These relationships were all expected with higher scores of alexithymia and with higher scores of optimism independently.

2.2 Method

2.2.1 Participants

This study recruited 50 healthy male and female participants (m=37, f=13) between the ages of 18-60 years (M=28.36, SD=10.89). Participants were engaged in vigorous endurance exercise at least once per week (M=8.46hr, SD=5.4hr) and had a maximal aerobic capacity ($\dot{V}O_2$max of 51.26 (SD=6.98) ml.kg.min). To minimize the impact of fluctuations in sex hormones on endocrine measurements (Mee et al., 2015; Stephens et al., 2016) female participants were included if they had athletic amenorrhea, contraceptive-induced amenorrhea, or a regular menstruating cycle. Participants with a regular menstrual cycle were tested during the follicular phase (day 1 to 10), the placebo phase of the oral contraceptive and individuals who were amenorrhoeic were not tested at a specific time. The study received Bangor University ethics approval which follows the Declaration of Helsinki and all participants provided written informed consent before participating. Prizes were awarded in this study for the 1st, 2nd and 3rd fastest time over the 2nd 3kTT. The cost of these prizes was respectively was £100, £75, £50.

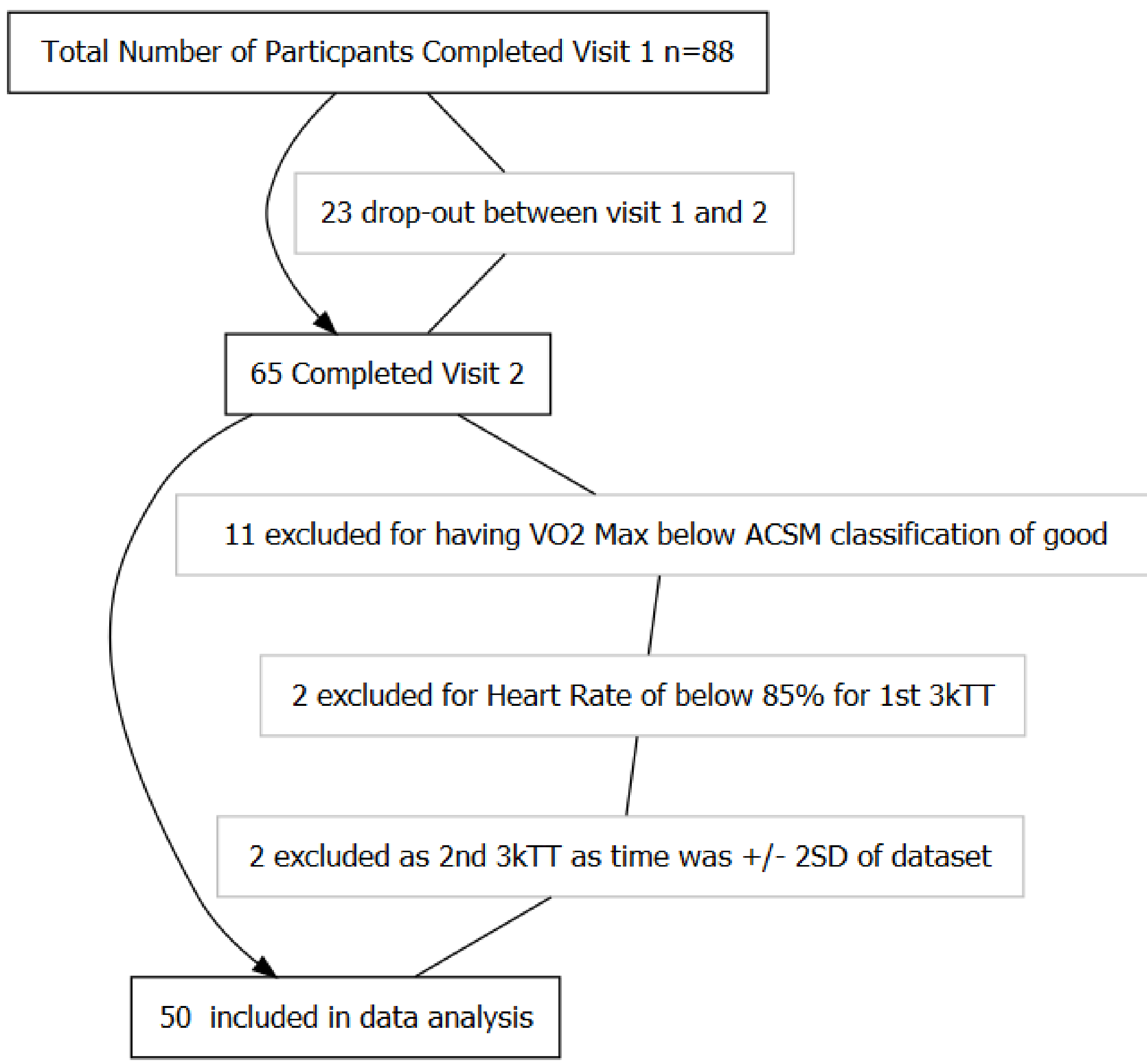


Figure 2.1: Study Participants ($N = 50$): Participant drop out from Visit 1 to 2 and exclusion

2.2.2 Study Design

The study involved two visits to the laboratory (Figure 1). The first visit was for preliminary testing to determine maximal aerobic capacity and running speed for Visit 2 and familiarization with the 3KTT. Personality questionnaires were also completed during the first visit. During the second experimental visit, participants completed two bouts of vigorous aerobic running exercise, separated by a 75 min recovery period. During this visit, recovery was measured by the PRS scale, cortisol and DHEA concentrations (Saliva) and subsequent performance (2nd 3kTT time). To minimize the influence of diurnal variation on performance and salivary hormones, participants completed their visits between 2 pm and 6 pm (Dorn et al., 2007). Before each visit, participants were asked to maintain the same dietary intake. Participants were also asked to refrain from: alcohol, nicotine and vigorous exercise 48 h prior, any exercise 24 h prior and caffeine 12 h before each visit.

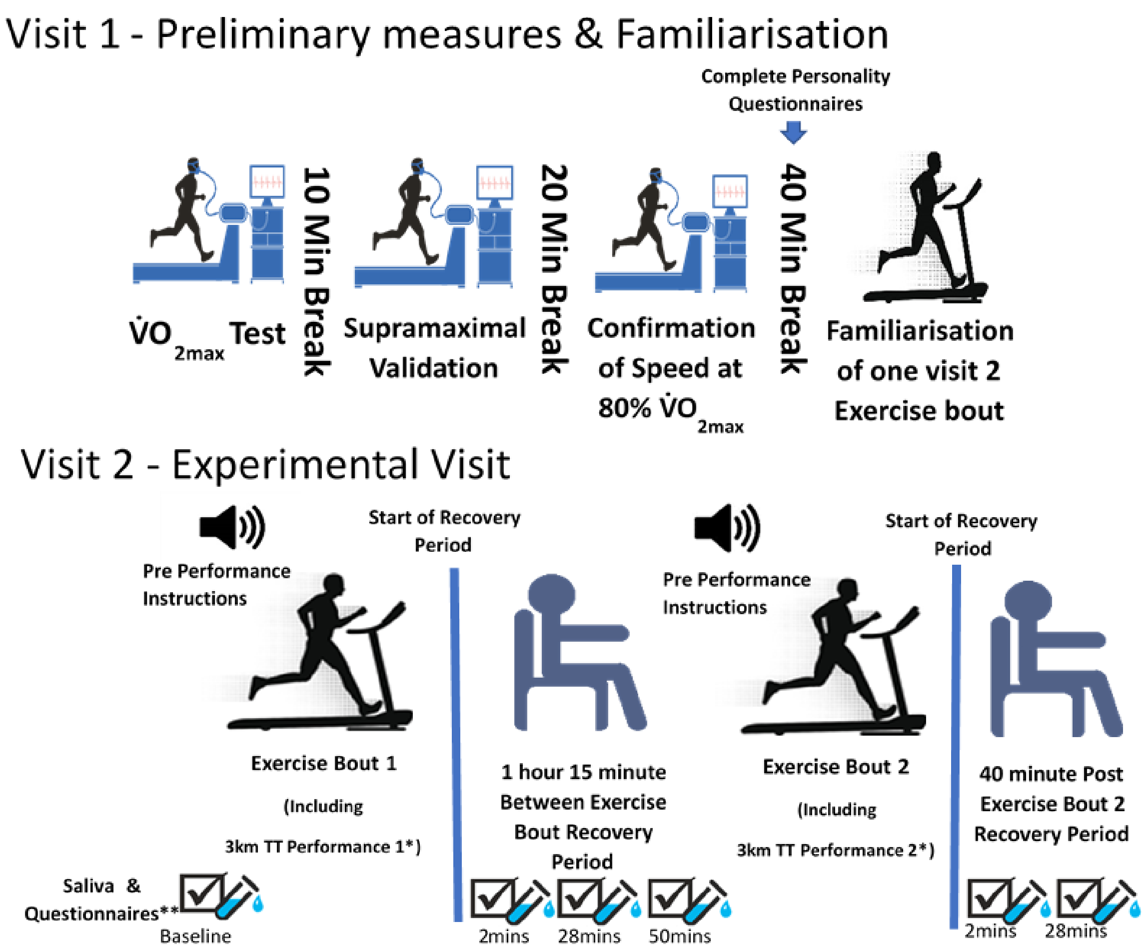


Figure 2.2: Schematic representation of the two labratory visits: Particpants were running with a mask connected to metabolic cart symbolised with the blue treadmill and no metabolic cart or mask when a black treadmill is displayed. All breaks and recovery periods were seated rest with standardised periods of standing and moving for one minute. Pre-performance instruction were pre-recorded and played again at a standardised time across particpants.*Exercise Bout make up: Before the 3km time trial performance there was a 5 min self-paced warm up and a 10 min preload which was run at the speed participants were at 80% VO2max. **PRS was recorded first at the time points labelled, then the saliva sample was taken 2 minutes later always at the same time across particpants, 4, 30 and 52 min and collection lasted for 5-7 min.

2.2.3 Procedures

2.2.3.1 Maximal Aerobic Capacity ($\dot{V}O_2$max Test)

The $\dot{V}O_2$max test was an incremental treadmill run to volitional exhaustion commenced at 1% treadmill gradient at a speed of 10 km · hr, and increased by 1km · hr every minute until a speed of 16 km · hr, at which point the gradient was increased by 1% every minute until exhaustion. Oxygen consumption was recorded continuously throughout the test by a metabolic cart (Metalyser, Cortex, Leipzig, Germany) with $\dot{V}O_2$max defined as the highest 30 s average at any given time point (Hill et al., 2002). Additionally, during the final 15 s of each incremental stage recordings of heart rate (HR) were made by a remote transmitter (FT3, Polar, Kempele, Finland) and the CR-10 scale (Borg, 1998) was also recorded. $\dot{V}O_2$max was verified by runners returning to the treadmill to complete a supramaximal validation after the $\dot{V}O_2$max test in Visit 1. This involved running again at one intensity greater than at exhaustion (i.e. 1% greater gradient) 10 min after they had completed the $\dot{V}O_2$max test.

2.2.3.2 Exercise Preload Speed (Confirmation of speed at 80% $\dot{V}O_2$max)

For the exercise task in Visit 2 participants were required to run for 10 min at a speed equal to 80% of their $\dot{V}O_2$max as a preload before immediately running a 3KTT. To determine this speed again a metabolic cart was used during Visit 1. A running speed equivalent to 80% of the participants $\dot{V}O_2$max was assessed calculating 80% of a participants $\dot{V}O_2$max and looking at the speed the participant was running when this occurred during the $\dot{V}O_2$max test. This was then used as the starting speed when the participant mounted the treadmill for the confirmation stage in Visit 1. Researchers then altered the speed of the treadmill over a period of at least five minutes but no more than 10 minutes to find the speed at which participants were steadily running at 80% of their $\dot{V}O_2$max. This speed was recorded and then used in Visit 2 as the participants' preload speed.

2.2.3.3 Exercise Bout Familiarisation

Familiarisation with the exercise bout that was used during Visit 2 occurred once during Visit 1. This familiarisation consisted of a 5-min self-paced treadmill warm-up followed by a 10-min constant load run at the speed corresponding to the individuals 80% $\dot{V}O_2$max speed from the earlier calculated preload speed, followed immediately by a self-paced 3kTT where participants were able to alter the speed they were going. All exercise was performed at a 1% treadmill gradient to simulate conditions similar to being outdoors (Jones & Doust, 1996).

2.2.3.4 Exercise Bouts 1 & 2

During Visit 2, participants completed the same exercise bout twice, separated by 75min. Both exercise bouts were identical to the familiarisation exercise bout. Throughout each exercise bout, all participants were able to see the distance they had run and were able to alter the speed of the treadmill themselves during the warm-up and 3kTT component. Participants were however unable to see their speed or time. The purpose of these exercise bouts was to induce a state of fatigue that necessitates recovery and to provide a marker of subsequent exercise performance. Heart rate and Rating of Percieved E (Borg, 1982) were recorded at one-minute intervals during the 10-min preload and at 500m intervals throughout the 3kTT. Heart rate (HR) was obtained continuously from a wetted Polar RS800cx chest-strap (HRM; Polar Electro OY, Kempele, Finland) across both visits. These readings were used to ensure participants tried hard in both 3kTT performances with a HR of above 85% of their HR Max if HR was not above 85% HR max in the 1st 3kTT then participants were excluded from the analysis.

2.2.3.5 Post Exercise Recovery Period

During the 75 min recovery period that elapsed between the two exercise bouts of Visit 2, and again, after the second exercise bout (50 min), every participant completed the same procedure and measures. Participants were seated throughout each recovery period but were asked to stand up and walk around for one minute at standardised times. The duration of these recovery periods was consistent for all participants. Participants were not allowed to eat or drink until after the final saliva measure. This was due to the repeated taking of saliva samples over the recovery periods and the interference eating or drinking may have had on the saliva samples (Mandel, 1987; Toda et al., 2004).

2.2.3.6 Pre-Performance Instructions

Before each exercise bout participants were played pre-recorded instructions. These were used to ensure participants knew they needed to try hard on both exercise bouts rather than intentionally conserving effort on the first 3kTT so as to perform better on the second 3kTT. The instructions were "This is a race. The winner of the prize money will be the participant that completes the second 3kTT with the 'best' individual performance in relation to their first 3kTT. To ensure every runner performs maximally, as you would in a race, we will assess your heart rate throughout the time trials. Only those runners that maintain at least 90% heart rate max during both time trials will be eligible to win the prize money. 1st prize will receive £100, second prize £50 and third prize £25. It is therefore important that you try your hardest on both trials so that you are eligible to win a prize, it is a competition. The three best individual times will be e-mailed to everyone at the end of the study. Good luck – Now race hard!"

2.2.3.7 Saliva Collection & Analysis

Saliva samples were obtained on six occasions during the Visit 2 with each sample taken for 5 or 7 minutes dependant on flow rate. The first was taken at the start of the visit, then three samples were taken during the 75min recovery period that elapsed between exercise bouts. These were taken at 4, 30 and 52 minutes respectively. Finally, two samples were taken after the second exercise bout at 4 and 30 minutes respectively. Saliva samples were collected using the same technique as described previously in detail (Oliver et al., 2007). In brief, unstimulated whole saliva samples were collected using pre-weighed universal tubes. Saliva samples were collected while the participant sat quietly in the laboratory. The saliva sample was then collected for 5 or 7 min (dependent on flow rate) by the participant leaning forward and passively drooling into the tube with minimal orofacial movements. Saliva volume was estimated by weighing the universal tube immediately after collection to the nearest milligram. The saliva was then centrifuged for 15 minutes at 3000 rpm, and pastetted into Eppendorfs, and stored at -15°C for the duration of the visit, before being stored at -80°C until biochemical analysis. Assuming a saliva density of 1 g · ml (Cole & Eastoe, 1988) saliva flow rate was determined by dividing the volume of saliva by the collection time. Salivary cortisol and DHEA concentrations were determined using commercially available enzyme-linked immunological assays (ELISA) specifically designed for saliva (Salimetrics Salivary cortisol ELISA Kit, Salimetrics, LLC.). Both cortisol and DHEA were measured using competitive ELISA that measures the unbound cortisol or DHEA in the saliva by binding it to an enzyme conjugate and then measuring optical density.

2.2.3.8 Questionnaires

Questionnaires were completed using QualtricsXM an online platform which was used for the collection of questionnaire-based data. QualtricsXM is frequently used in scientific research as a platform to collect questionnaire data when no direct contact is required with the participant. It was used in this study to avoid transfer error from paper to the computer as the data was just directly downloaded from Qualtrics. Participant's responses were saved to Qualtrics using their unique identifying code. Participants completed the personality questionnaires during Visit 1. Participants completed perceptual questionnaires during Visit 2 at baseline and then at multiple points throughout both recovery periods. The questionnaires were always asked in the same order during each recovery period and at the same time during the recovery period across all participants, e.g. PRS Scale was asked at 2mins, 28mins and 50mins from the end of the 1st 3kTT.

2.3 Measures

2.3.1 Subsequent Performance on 3kTT

Time to completion was covered on both 3kTT. Subsequent Performance was measured simply as the time taken to complete the 2nd 3kTT when controlling for the 1st 3kTT time.

2.3.2 Questionnaires and Scales

Two measures of personality, perceived recovery status, and a perceived fatigue measure were collected. The personality traits measured were alexithymia (TAS-20; Bagby et al. (1994)) and optimism (LOT-R; Scheier et al. (1994)). Perceived recovery was measured using the PRS Scale (Laurent et al., 2011). In addition, fatigue was measured using the fatigue subscale of the Brunel Mood Scale (BRUMS;

Terry et al. (1999)) and Anxiety using the state section of the State Trait Anxiety Index (STAI; Spielberger (1983)).

2.3.2.1 Personality

The Toronto Alexithymia Scale (TAS)-20 (Bagby et al., 1994) was used to measure alexithymia. It has been previously used in several sports studies when studying alexithymia in high-risk sports (Cazenave et al., 2007; Woodman et al., 2010). The TAS-20 is comprised of 20 items to assess the alexithymia construct through three main facets: Difficulty Identifying Feelings, DIF, (e.g., I am often confused about what emotion I am feeling); Difficulty Describing Feelings, DDF, (e.g., It is difficult for me to find the right words for my feelings); Externally Oriented Thoughts, EOT, (e.g., I prefer to analyse my problems rather than just describe them). Items are rated on a five-point Likert scale ranging from 1 (Strongly disagree) to 5 (Strongly agree). A total alexithymia score is calculated by combining the three sub-scale scores for the total score (high scores equate to high alexithymia). Parker et al. (2003) reported internal reliability coefficients ranging from α= 0.73 to α= 0.84.

Optimism was be measured using the Life-Orientated Test-Revised (LOT-R) version (LOT-R, Scheier et al. (1994)). The LOT-R consists of 10-items each of which has a 5-point Likert scale from 1-I disagree a lot, to, 5- I agree a lot. The LOT-R shows internal consistency α=.78 and test-retest reliability (r = .68) over a four-week interval(Czech et al., 2002)

2.3.2.2 Perceived Recovery

The PRS scale was developed by Laurent et al. (2011) and uses a single scaled item to assess the perceived recovery. The PRS scale is a 0–10, scalar representation of varying levels of an individual's PRS. The PRS scale was collected at 2 minutes, 28 minutes and 50 minutes in between bouts and 2 and 28 minutes after exercise bout 2. In this instance, PRS ratings were anchored to the previous exercise bout "Please write down a number that best describes your level of recovery from the previous exercise bout".

2.3.2.3 Perception of Fatigue (BRUMS)

Fatigue was measured using the fatigue scale from the BRUMS (Terry et al., 1999). Participants indicated the extent to which they felt worn-out, exhausted, sleepy and tired before running on the treadmill both times and during the recovery periods between exercise bout and after the second exercise bout. Participants responded on a scale from 0 (not at all) to 4 (extremely). The BRUMS was collected prior to the first exercise bout, at 20, 46, and 67 minutes in between bouts and 20 and 46 minutes after the second exercise bout.

2.3.2.4 Anxiety (STAI)

Anxiety was measured using the STAI (Spielberger, 1983). The STAI has two section a trait and a state form. For this study the form Y (state) questionnaire was used to measure participants' state anxiety. The STAI was collected prior to the first exercise bout, at 20, 46, and 67 minutes in between bouts and 20 and 46 minutes after the second exercise bout.

2.4 Statistical Analysis

2.4.1 Preliminary Analysis

We removed participants who failed to maintain: a HR above 85% HR max in both the first and second 3kTT, participants who were not classed as good or above on ACSM $\dot{V}O_2$max classification and finally anyone whose second 3kTT time was not with +/-2 *SD* of their first 3kTT.

To examine the recovery from exercise over the recovery period between exercise bout one and two, we calculated the area under the curve from the three collection points obtained during this recovery period for PRS, cortisol, DHEA and the cortisol:DHEA ratio. From this curve (Figure 2.3), Area under the curve with respect to ground (AUCg), Area Under the Curve with respect to baseline (AUCb) and Area under the curve with respect to increase (AUCi) were obtained using the same techniques as (Fekedulegn et al., 2007; Pruessner et al., 2003).

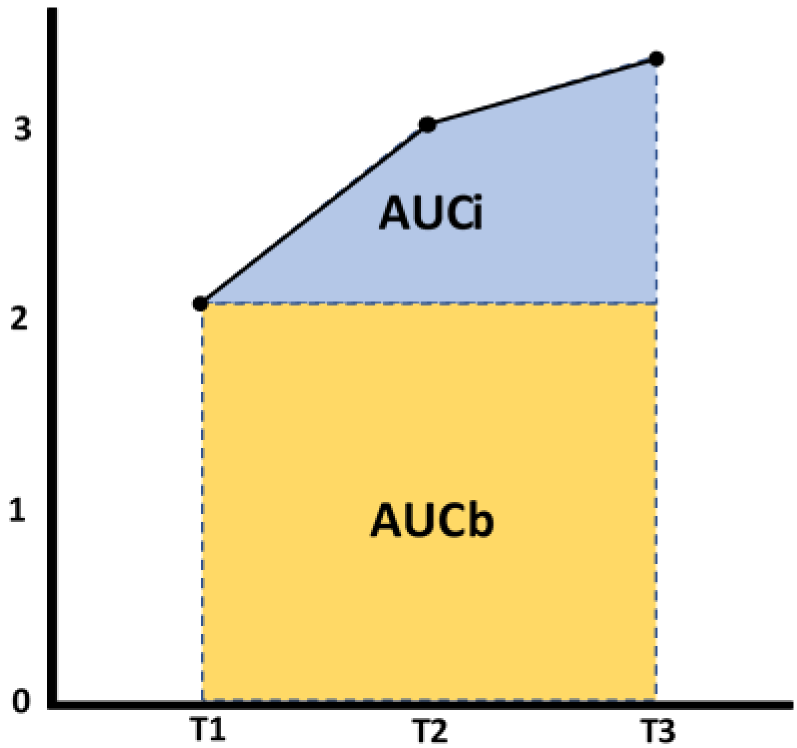


Figure 2.3: Different Area under the Curves (AUC's): AUCb reflects the area from zero which is consistant across all individuals and to their invidiual baseline and therefore allows investigation of an individualls baseline (time 1) perceptual or endocrine response at the start of the recovery period. AUCi represents the area under the curve above an individuals baseline only and allows for an investigation into the response from an indivduals baseline over the recovery period. AUCg = AUCi + AUCb, AUCg gives a representation of an indviduals overall response from zero.

To calculate the cortisol:DHEA ratio we divided cortisol by DHEA. A smaller number indicated a better balance of cortisol and DHEA a larger number indicates greater levels of cortisol compared to DHEA (Heaney et al., 2014). Simple correlations were performed between alexithymia and optimism, and the following: $\dot{V}O_2$max, training hours and preload speed. This was to ensure that any effects of personality on time to complete the time trials was not simply a function of higher fitness. Neither alexithymia or optimism were significantly correlated with preload speed (r = 0.2, r = 0.0), $\dot{V}O_2$max (r = 0.2, r = 0.1) or weekly training hours (r = 0.2, r = 0.2) r values displayed respectively for alexithymia and optimism. In addition we also ran correlations between alexithymia and optimism with anxiety across the study and average 3kTT effort measured by RPE and heart rate (Table 2.1) given these may have a baring on alexithymic and optimistic individuals post-exercise recovery. Alexithymia had a weak but significant negative correlation with average RPE on the first 3kTT (r = -0.31, p = 0.04) and optimism had a weak but significant negative correlation with anxiety 20 min after the first exercise bout (r = -0.31, p = 0.04).

Table 2.1: Alexithymia and Optimism's correlations with and anxiety and Effort

	Alexithymia		Optimism	
	r	P-Value	r	P-Value
Anxiety Pre	0.03	0.84	-0.08	0.62
Anxiety T1	-0.02	0.19	-0.31	0.04
Anxiety T3	-0.06	0.69	0.01	0.96
Anxiety T4	0.02	0.91	0.17	0.27
1st 3kTT RPE	-0.31	0.04	0.08	0.59
2nd 3kTT RPE	-0.19	0.21	0.22	0.16
1st 3kTT HR	0.00	0.98	-0.14	0.36
2nd 3kTT HR	0.05	0.77	0.03	0.84

Note: 3kTT variables are an average from across the 3kTT, Anxiety measures are prior to the first exercise bout, 20 min and 67 min after the 1st exercise bout and 20 min after 2nd exercise bout

The recovery period following the second 3kTT was only 50 minutes in length. We therefore, used only the 30-minute saliva sample recording to assess endocrine markers during this recovery period as we believed this time period allowed for peak concentration to be reached (as demonstrated in the first recovery period). As a result of using a single time point for cortisol and DHEA, data were transformed using a natural log to remove skewness, before running the linear regression models.

2.4.2 Main Analysis

Analysis was conducted using R Statistical Software (v4.1.2; R Core Team 2021) using stats version 4.0.3 to run linear regression, tables were produced using package kableExtra (Zhu,2021) and figures were produced using the package ggplot2 (Wickham, 2009). Regressions were run using an alpha level of 0.05 and effect sizes were calculated using Cohens f^2 (Cohen, 1977). For this manuscript, the simplest models (models with no covariates) are presented, models with covariates were only included and presented if they had a significant effect on the regression model. The models which included covariates were as such, for subsequent performance on the second 3kTT, we included the time taken to complete the first 3kTT as a covariate in all subsequent performance models. For the perceived recovery models baseline BRUMS fatigue was used as a covariate in the between exercise bout models, the BRUMS fatigue score prior to the second exercise bout did not have a signifcant effect onPRS after the second exercise bout as such it was not included as a covariate in these models.Finally, models which did not include covariates were for the HPA axis marker models, we added baseline hormone concentrations, age and sex to each of the regression models for cortisol, DHEA and the ratio, however, none of these covariates had a significant effect on the outcome so are not reported in the results.

2.5 Results

The results section is presented in three sections. First, recovery markers with exercise bouts without personality, the second personality with between exercise bouts recovery period markers (primary aim), and finally personality with post-exercise bout two recovery period (secondary aim).

2.5.1 Recovery Markers and Exercise Results

This section displays the response of the perceptual and endocrine recovery markers to the exercise bouts across all individuals before analysing for personality (Figure 2.4). This is to demonstrate the effect of the exercise on our recovery markers prior to personality being included in the analysis. This section also includes the individual and average performance of participants in the first and second 3kTT's before analysing for personality (Figure 2.5).

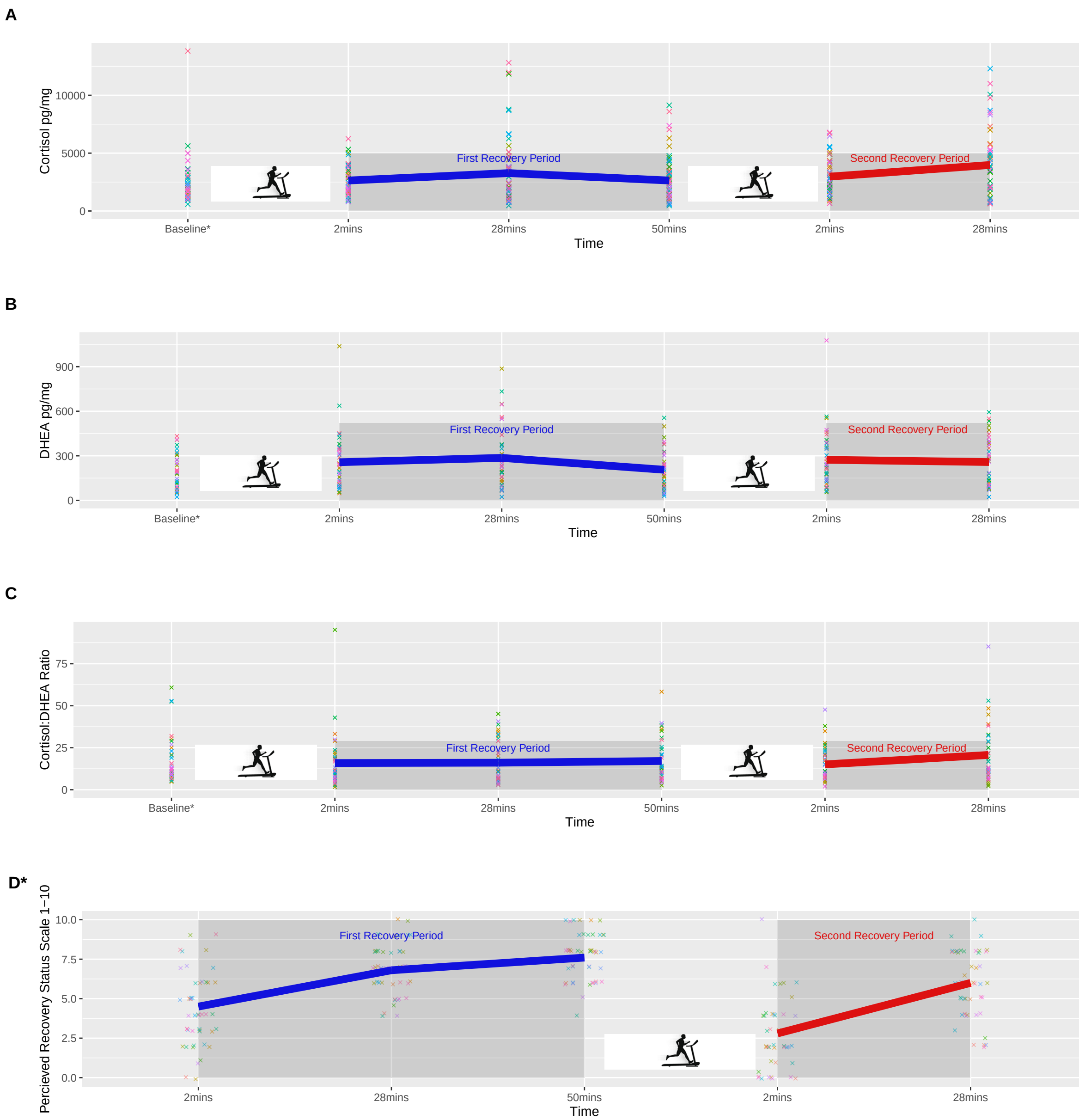


Figure 2.4: Recovery marker trajectories without influence of Alexithymia or Optimism: Each panel of this figure represents each recovery marker measured A = Cortisol, B= DHEA, C = Cortisol:DHEA Ratio and D = Perceived Recovery Status (PRS) Scale. The coloured line represent the mean concentration or score of each marker and the points represent the individual data. *PRS has no average datapoint for baseline as there is nothing to perceive recovery from

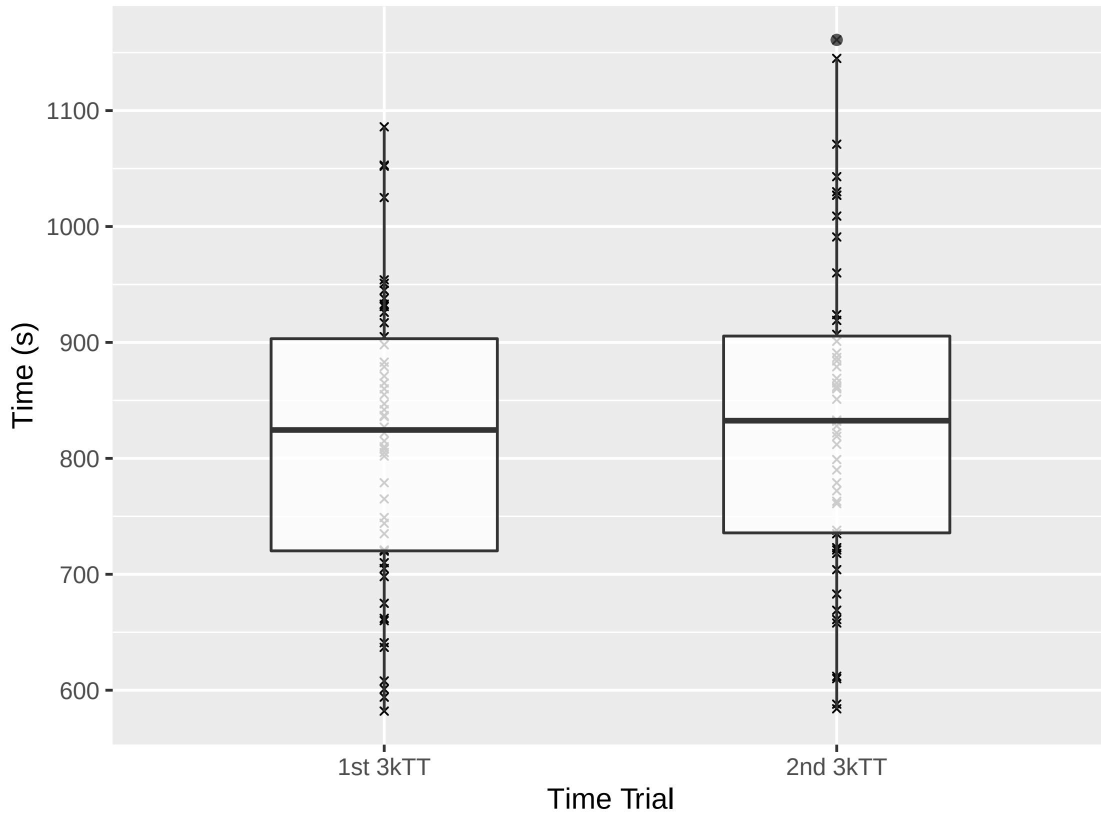


Figure 2.5: Particpants 3kTT times: Display of the average time trial time for each 3kTT. The crosses represent the individual data, average time for 1st 3kTT 815s, for the 2nd 3kTT 837s

2.5.2 Recovery period between exercise bouts (75 min)

This recovery period is analysed through subsequent performance, perceptual recovery, and HPA axis markers.

2.5.2.1 Subsequent 3km Running Time Trial Performance (3kTT)

Alexithymia

Subsequent 3kTT Performance was measured as the time taken to complete the second 3kTT whilst controlling for the first 3kTT as a co-variate. When controlling for the first 3kTT time, greater levels of alexithymia were associated with completing the second 3kTT more quickly(R^2=0.89, F(2,47)=182.62, p = 0.05). The R^2 change for alexithymia in the model was equal to 0.01 although this effect represents a small effect size Cohen's f^2=0.09. It is noteworthy that alexithymia did explain 1% of the 20% of variance left to be explained in the model once the time for the first 3kTT was accounted for (Table 1), with the regression coefficients suggesting that every unit increase in alexithymia improves performance by 1.1 s. Therefore, using the established alexithymia cut-offs (Taylor et al., 1988) individuals high in alexithymia TAS-20 score >= 61 would be at least 11 s faster on the second 3kTT than individuals low in alexithymia <=51.

Table 2.2: Regression Model including 1st 3kTT time, Alexithymia and Subsequent Performance

	Estimate	*SE*	*LL*	*UL*	*p*
(Intercept)	60.5	56.28	-52.74	173.7	0.29
Time 1st 3k	1.0	0.05	0.91	1.1	0.00
Alexithymia	-1.2	0.59	-2.39	0.0	0.05

Note: LL,UL are abbreviations of the lower level and upper level 95% confidence intervals respectively

Optimism

There were no effects of trait optimism levels on subsequent performance (R^2=0.88, F (2,47)=171.85, p = 0.25)

Table 2.3: Regression Model including 1st 3kTT time, Optimism and Subsequent Performance

	Estimate	*SE*	*LL*	*UL*	*p*
(Intercept)	44.5	64.12	-84.46	173.5	0.49
Time 1st 3k	1.0	0.06	0.93	1.2	0.00
Optimism	-3.2	2.75	-8.74	2.3	0.25

Note: LL,UL are abbreviations of the lower level and upper level 95% confidence intervals respectively

2.5.2.2 Perceived recovery

Alexithymia

AUCb PRS scale score at the start of the recovery period

Once controlling for BRUMS fatigue prior to the first 3kTT, alexithymia accounted for 7% of the remaining variance in AUCb (R^2=0.07,R^2change=0.07, F (2,45)=1.8, p = 0.06).This effect approached significance and indicated that higher levels of alexithymia were associated with higher AUCb scores (indicative of better recovery).

AUCi PRS scale score increase or decrease over the recovery period from the start of the recovery period

Once controlling for BRUMS fatigue prior to the first 3kTT, alexithymia accounted for less than 1% of the remaining variance in AUCi (R^2=0.05,R^2change <0.01, F (2,44)=1.12, p = 0.34). This effect was not significant, higher levels of alexithymia were not associated with higher AUCi scores (not indicative of better recovery). The was no relationship between alexithymia and AUCi.

AUCg PRS scale score increase or decrease over the recovery period from zero

Once controlling for BRUMS fatigue prior to the first 3kTT, alexithymia accounted for 15% of the remaining variance in AUCg(R^2=0.23, R^2change=0.15, F (2,44)=6.62, p = .01). This effect approached significance and indicated that higher levels of alexithymia were associated with higher AUCg scores (indicative of better recovery). The relationship between alexithymia and AUCg was positive and approached significance.

Table 2.4: Regression Model including BRUMS Fatigue, Alexithymia PRS AUC Baseine

	Estimate	*SE*	*LL*	*UL*	*p*
(Intercept)	112.2	93.9	-77.0	301.3	0.24
BRUMS Fatigue Prior to Bout 1	-11.1	33.8	-79.1	56.9	0.74
Alexithymia	3.1	1.6	-0.2	6.4	0.06

Note: LL,UL are abbreviations of the lower level and upper level 95% confidence intervals respectively

Table 2.5: Regression Model including BRUMS Fatigue, Alexithymia PRS AUC Ground

	Estimate	*SE*	*LL*	*UL*	*p*
(Intercept)	324.3	53.66	216.14	432.4	0.00
BRUMS Fatigue Prior to Bout 1	-47.4	19.25	-86.20	-8.6	0.02
Alexithymia	2.7	0.93	0.84	4.6	0.01

Note: LL,UL are abbreviations of the lower level and upper level 95% confidence intervals respectively

Optimism

There was no relationship between optimism and PRS scale when controlling for BRUMS fatigue prior to the 1st 3kTT with and areas under the curve. There was no relationship at the start of the recovery period AUCb (R^2=0.02,F (2,45)=0.38,p = 0.68). There was no relationship between optimism and PRS scale in increase from baseline over the recovery period AUCi (R^2=0.05,F (2,44)=1.26,p = 0.29). Finally, no relationship between optimism and overall response from 0 on the PRS scale over the recovery period AUCg=(R^2=0.09,F (2,44)=2.26, p = 0.47). Table 4 shows model results for AUCg only as this incorporates AUCb and AUCi.

Table 2.6: Regression Model including BRUMS Fatigue, Optimism PRS AUC Ground

	Estimate	*SE*	*LL*	*UL*	*p*
(Intercept)	385.5	91.4	201.3	569.8	0.00
BRUMS Fatigue Prior to Bout 1	-42.1	20.8	-84.1	-0.2	0.05
Optimism	3.3	4.5	-5.8	12.5	0.47

Note: LL,UL are abbreviations of the lower level and upper level 95% confidence intervals respectively

2.5.2.3 Ratio, Cortisol and DHEA Response

The respective raw hormonal values at 5, 30 & 52 minutes were used to calculate the area under the curve for each HPA axis marker (namely cortisol, DHEA and their

Ratio) during the recovery period between exercise bouts. There was a significant effect of cortisol response between exercise bouts and the time to complete the 1st 3kTT, but there was no significant effect of the 1st 3kTT time on DHEA or cortisol:DHEA ratio during the recovery period between exercise bouts.

2.5.2.3.1 Cortisol:DHEA Ratio

Alexithymia

AUCb Ratio scale score at the start of the recovery period

Once controlling for first 3kTT time, alexithymia accounted for 1% of the remaining variance in AUCb (R^2 =0.12, R^2change =0.01, F (2,42)=2.75, p = 0.56). This effect was not significant and did not indicate that higher levels of alexithymia were associated with lower AUCb scores (indicative of better recovery). There was no relationship between alexithymia and AUCb.

AUCi Ratio scale score increase or decrease over the recovery period from the individuals baseline at the start of the recovery period

Once controlling for first 3kTT time, alexithymia accounted for 1% of the remaining variance in AUCi (R^2=0.18,R^2change =0.01, F (2,41)=4.39, p = 0.33). This effect was not significant and did not indicate that higher levels of alexithymia were associated with lower AUCi scores (indicative of better recovery). There was no relationship between alexithymia and AUCi.

AUCg Ratio scale score increase or decrease over the recovery period from zero

Once controlling for the first 3kTT time, alexithymia accounted for 2% of the remaining variance in AUCg (R^2=0.17,R^2change=0.02, F (2,41)=4.21, p = 0.01). This effect was significant and indicated that higher levels of alexithymia were associated with lower AUCg scores (indicative of better recovery). The relationship between alexithymia and AUCg was negative and significant.

Table 2.7: Regression Model including covariates, Alexithymia and Cortisol:DHEA Ratio

	Estimate	*SE*	*LL*	*UL*	*p*
AUCb					
Intercept	1333.15	538.11	247.2	2419.10	0.02
1st 3kTT(s)	-1.05	0.50	-2.0	-0.05	0.04
Alexithymia	3.45	5.91	-8.5	15.38	0.56
AUCi					
Intercept.	2312.62	588.18	1124.8	3500.47	0.00
1st 3kTT(s).	-1.54	0.54	-2.6	-0.45	0.01
Alexithymia.	-6.46	6.59	-19.8	6.84	0.33
AUCg					
Intercept,	989.24	330.18	322.4	1656.06	0.00
1st 3kTT(s),	-0.48	0.30	-1.1	0.13	0.12
Alexithymia,	-10.11	3.70	-17.6	-2.64	0.01

Note: LL,UL are abbreviations of the lower level and upper level 95% confidence intervals respectively

Optimism

There was no significant relationship between optimism and any area under the curve approach for cortisol:DHEA ratio (AUCb, R^2=0.11, F(2,42)=2.57, p = 0.94, AUCi, R^2 =0.04, F(2,41)=0.79, p = 0.74, AUCg,(R^2 =0.15, F(2,41)=3.71, p = 0.49).

Table 2.8: Regression Model including covariates, Optimism and Cortisol:DHEA Ratio

	Estimate	*SE*	*LL*	*UL*	*p*
AUCb					
Intercept	1510.2	560.08	379.91	2640.50	0.01
1st 3kTT(s)	-1.1	0.50	-2.12	-0.11	0.03
Optimism	2.0	24.33	-47.12	51.07	0.94
AUCi					
Intercept.	2069.6	611.66	834.35	3304.88	0.00
1st 3kTT(s).	-1.4	0.54	-2.51	-0.32	0.01
Optimism.	-9.0	26.56	-62.64	44.62	0.74
AUCg					
Intercept,	559.2	367.45	-182.85	1301.31	0.14
1st 3kTT(s),	-0.3	0.33	-0.96	0.36	0.36
Optimism,	-11.0	15.95	-43.21	21.23	0.49

Note: LL,UL are abbreviations of the lower level and upper level 95% confidence intervals respectively

2.5.2.3.2 Cortisol and DHEA independently

Alexithymia

There were no effects for alexithymia on cortisol alone or DHEA alone between the two exercise bouts for any of the areas under the curve. This means there was no relationship between alexithymia and cortisol or DHEA concentrations at the start of the recovery period AUCb (cortisol,(R^2 =0.13, F(2,47) = 3.6, p = 0.33), DHEA, R^2 = 0, F (2,47) = 0.04, p = 0.96). There was no relationship between alexithymia and the cortisol or DHEA response from baseline over the recovery period AUCi (cortisol, R^2 =0.02, F(2,47)=0.5, p = 0.61, DHEA R^2=0.02, F(2,47) = 0.58, p = 0.56). Finally, there was no relationship between alexithymia and overall response from 0 in cortisol or DHEA concentrations over the recovery period AUCg (cortisol, R^2 = 0.11, F (2,46)= 2.73, p = 0.08, DHEA, R^2=0.01, F(2,47)= 0.18, p = 0.83).

Optimism

There were no effects for optimism on cortisol alone or DHEA alone between the two exercise Bouts for any of the areas under the curve. This means there was no relationship between optimism and cortisol or DHEA concentrations at the start of the recovery period AUCb (cortisol,(R^2 = 0.14, F(2,47)= 3.81, p = 0.53), DHEA, R^2 =0, F(2,47)= 0.07, p = 0.74). There was no relationship between optimism and the cortisol or DHEA response from baseline over the recovery period AUCi (cortisol, R^2 = 0.01, F(2,47)= 0.17, p = 0.91, DHEA, R^2 = 0.02, F(2,47)=0.58, p = 0.99). Finally, there was no relationship between optimism and overall response from 0 in cortisol or DHEA concentrations over the recovery period AUCg (cortisol, R^2 = 0.11, F(2,46) = 2.91, p = 0.46, DHEA, R^2=0.01, F(2,47) = 0.19, p = 0.81).

Table 2.9: Summary of between exercise bouts recovery results

	Alexithymia			Optimism		
	r^2	p	Predictor	r^2	p	Predictor
Subsequent Performance	0.89	0.05	Negative	0.88	0.25	N/A
PRS AUCb	0.07	0.06	Positive	0.02	0.68	N/A
PRS AUCi	0.05	0.34	N/A	0.05	0.29	N/A
PRS AUCg	0.23	0.01	Positive	0.09	0.47	N/A
Cortisol:DHEA Ratio AUCb	0.12	0.56	N/A	0.11	0.94	N/A
Cortisol:DHEA Ratio AUCi	0.18	0.33	N/A	0.04	0.79	N/A
Cortisol:DHEA Ratio AUCg	0.17	0.01	Negative	0.15	0.49	N/A

2.5.3 Recovery after Exercise Bout 2 (50 min)

This third set of results looks at the secondary aim, the 50 minute recovery period after the second exercise bout. This period is analyzed through perceptual recovery and HPA axis Markers

2.5.3.1 Perceived recovery

Perceived recovery were analysed by analysing the PRS scale recorded at 28 minutes post-exercise bout 2. After the second bout of exercise there are no significant effects for personality alexithymia or optimism on perceived recovery (Alexithymia, (R^2=0.01, F (1,45)=0.23, p = 0.48), optimism, R^2=0.02, F (1,45)=0.77, p = 0.88).

2.5.3.2 Cortisol, DHEA and Ratio 30 minutes post-bout two

There is a significant effect of the 2nd 3kTT on cortisol response 30 minutes post-exercise bout 2 (R^2=0.07, F (1,47)=3.3, p = 0.08).

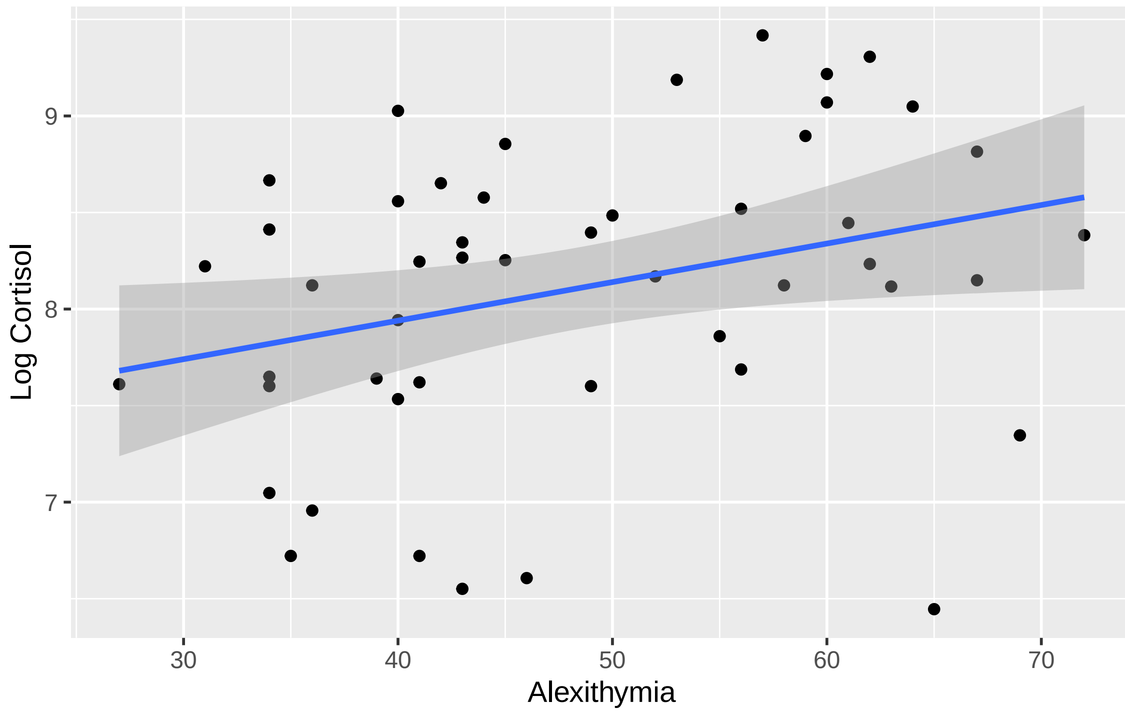
2.5.3.2.1 *Cortisol*

Alexithymia

Once controlling for the 2nd 3kTT time, alexithymia accounted for 6% of the remaining variance in 30 minutes cortisol concentration (R^2=0.16, R^2 Change=0.06, F (2,46)=4.32, p = 0.07). This effect approached significance and indicated that higher levels of alexithymia were associated with higher cortisol concentration (indicative of worse recovery). The relationship between alexithymia and 30 minutes cortisol concentration was positive and approaching significant.

Optimism

Once controlling for the 2nd 3kTT time, optimism accounted for 4% of the remaining variance in 30 minutes cortisol concentration (R^2 =0.14, R^2 Change=0.04, F(2,46) = 3.59, p = 0.16). This was not significant and did not indicate that higher levels of optimism were associated with higher cortisol concentration (indicative of worse recovery). There was no relationship between optimism and 30 minutes cortisol concentration.



Relationship between Alexithymia and Log Cortisol 30 minutes post−exercise bout 2

2.5.3.2.2 *DHEA independently and Ratio*

There is no effects of personality on DHEA alone or the cortisol:DHEA ratio, 30 minute concentrations results were as follows alexithymia (DHEA, $R^2 = 0.06$, $F(2,37) = 1.19$, $p = 0.32$, Ratio, $R^2 = 0.14$, $F(2,37) = 2.9$, $p = 0.18$), optimism (DHEA, $R^2 = 0.01$, $F(2,37) = 0.23$, $p = 0.23$, Ratio, $R^2 = 0.1$, $F(2,37) = 2.13$, $p = 0.49$)

Table 2.10: Summary of post-exercise bout 2 results

	Alexithymia			Optimism		
	r^2	p	Predictor	r^2	p	Predictor
PRS	0.01	0.48	N/A	0.02	0.88	N/A
Cortsiol 30 min	0.16	0.07	Positive	0.14	0.16	N/A
DHEA 30 min	0.06	0.32	N/A	0.01	0.23	N/A
Cortisol:DHEA Ratio	0.14	0.18	N/A	0.01	0.49	N/A

2.6 Discussion

The primary aim of this study was to investigate the influence of personality on acute post-exercise recovery between two running based exercise bouts. A secondary aim was to investigate the influence of personality on acute post-exercise recovery after the second 3kTT. Across both aims, it was hypothesised that alexithymia would be related to a positive or better recovery. The alexithymia hypothesis was supported across most markers of post-exercise recovery in between exercise bouts. For example, the higher score an individual had in alexithymia the better their performance on the second 3kTT, higher perceived recovery scores and smaller cortisol:DHEA ratio concentrations between exercise bouts. After the second exercise bout, the alexithymia hypothesis was not supported with alexithymia not being related to most markers of recovery and instead had a positive relationship with cortisol concentrations, potentially showing worse recovery from exercise. Optimism was also hypothesised to be associated with better post-exercise recovery. The optimism hypothesis however was not supported with no relationships between optimism and any of the recovery markers, in either recovery period. Specifically, there was, no relationship with subsequent performance, no relationship with perceived recovery and no relationship with any endocrine markers.

2.6.0.1 Subsequent Performance, second 3kTT time

The greater an individual's alexithymia score the faster their second 3kTT when controlling for the first 3kTT. Despite alexithymia and subsequent performances relationship showing a small effect size when taken into the real world, that is a minimum difference of 11s between the established high and low alexithymia cut-offs (Taylor et al., 1997). Over a 3000m the top seven women and top eight men at elite level are covered by 11s at the diamond league events which were run over the last five years . It is appreciated that the population in this study is not elite however it does give some context to the difference 11s could make, this is however speculative due to the difference in populations. The relationship between alexithymia and subsequent 3kTT performance implies that the more alexithymic an individual the more recovered they are. These findings are novel in both exercise performance and post-exercise recovery. Previous literature has outlined theoretical reasoning for individuals with high trait alexithymia performing better in sport (Lopes et al., 2019;

Roberts & Woodman, 2015, 2017) however we believe this is the first study to support the theoretical standpoint. The findings of this study support those of previous researchers and show it is of merit to look further into the mechanisms behind why alexithymia has a relationship with subsequent performance and therefore recovery.

For optimism, there was no relationship with subsequent performance on the second 3kTT. The lack of relationship between optimism and subsequent performance is unexpected. Previous literature highlighted the theoretical rationale and evidence for optimists performing better (Roberts & Woodman, 2015). However, it was also highlighted that some of the previous evidence was weak between optimism and performance (Ortín-Montero et al., 2018) and this may be why this relationship didn't carry across to subsequent performance. Optimist's performance is very much tied to expectation, goals and achieving goals (Carver & Scheier, 2014). It is also known that optimists vary engagement depending on the importance of goals (Geers et al., 2009). In addition, Roberts & Woodman (2015) theorised an increase in the effort to help maintain or improve performance. It is, therefore, possible that this laboratory study did not feature high on our optimists' goal priority and therefore they were less engaged, did not increase effort supported by lack of correlation between optimism and effort (Table 2.1) and this may explain the lack of relationship with performance.

2.6.0.2 Perceived Recovery during first post-exercise recovery period (75 min)

Alexithymia's relationship with perceived recovery was as expected, in so far as the higher an individual is in alexithymia the greater their perceived recovery was. There is a variety of theoretical evidence behind why this relationship exists. The structured environment that a laboratory study creates may help as a framework onto which alexithymic individuals can lay their perceptions making the difficulty understanding their feelings easier. This rationale would be in line with the research by (Koole et al., 2015; Nemiah, 1977) about how structure helps to inform perceptions, however the use of structure has not been shown specifically in alexithymic individuals but theoretically it would be expected to be beneficial as alexithymic struggle with uncertainty (Ozsivadjian et al., 2020; Tekel & Korkman, 2020) and structure helps to remove uncertainty. This study potentially supports that alexithymics recovery benefits from strucutre as there was structure between the first and second exercise bouts which all participants were told about. This is supported further due to the lack of relationship between alexithymia and perceived recovery in the second recovery period which is open ended with no future focus and therefore lack of structure in terms of a recover period which has a performance after it.

Another area of literature that provides support for the perceptual finding is the use of exercise by alexithymics to regulate anxiety (Roberts & Woodman, 2015, 2017). Anxiety regulation may impact on the perceived recovery afterwards due to the positive affect potentially being felt. It is well established that exercise has an anxiolytic affect (Asmundson et al., 2013; Wipfli et al., 2008). Over time this anxiolytic affect wears off (Woodman et al., 2008) and can lead to individuals going in search of that feeling again and again. There is already literature linking alexithymia and exercise addiction which may be due to exercises anxiolytic effects immediately post-exercise. Acutely this study finds support for anxiolytic effects however it may not hold up more longitudinally as it is known anxiety increases again as soon as one hour after a stressor to above pre stressor anxiety scores (Roberts & Woodman, 2015; Woodman et al., 2008). It should be noted in this study there was no correlation between Alexithymia and anxiety at any time point however this analysis does not take into account changes over time. Finally, alexithymia has been linked with emotionally blunt responses (Roberts & Woodman, 2015). A emotionally blunt response may mean alexithymic individuals don't feel the negative emotions sometimes associated within the recovery period helping to perceive a greater recovery. Alexithymics potential use of a stimulus to regulate their emotions through the physical sensations caused by the stimulus (exercise in this case), combined with the structured recovery periods and blunted emotional response appears to allow alexithymics to thrive in this acute environment. The potentially effective use of structure by alexithymic individuals could potentially be applied to training plans showing the need for clear structured and potentially prescribed training sessions to allow alexithymics to successfully use exercise for emotional regulation.

Optimism showed no relationship with perceived recovery, contrary to the hypothesis. The lack of relationship between optimism and perceived recovery is potentially down to how the PRS scale was used and the expectation of the optimists. The lack of relationship may be because optimists did not expect to recover across the recovery period, the experimental design did not place any expectation on the recovery period being enough time to recover or that there was an expectation that participants would recover. This lack of expectation means that the positive relationship with optimism and placebo that has been previously demonstrated may not occur here unless the optimists themselves believe this as it was not manipulated in the experiment which was in the majority of research featured in Kern et al. (2020) review.

There was also not a negative relationship between optimism and perceived recovery which may have happened if optimists had engaged more effort during the performance (Geers et al., 2009; Roberts & Woodman, 2017) and therefore may have perceived they needed more recovery. There was no correlation between optimism and average perceived effort or heart rate during the 1st or 2nd 3kTT which may help to explain the lack of relationship as there is no evidence that optimists engaged more effort perceptually or physiologically during the 3kTT's. Finally, the PRS scale was asked in such a way that it was concerned about in the moment of recovery rather than expectation it asked: "how recovered to you feel from the previous bout of exercise" it did not ask "do you expect to recover by the next exercise bout" for example. This lack of expectation in how the PRS scale was asked during the study may further explain the lack of relationship as optimists may not be using their positive bias optimistic individuals place on the future (Sharot et al., 2007) and rather rating their perceived recovery at that moment which may not have the positive bias associated with optimists. The lack of expectation across the recovery period, lack of engagement of effort and how the PRS scale was asked may be why there is a lack of relationship between optimism and perceived recovery.

2.6.0.3 Cortisol and DHEA Response during first post-exercise recovery period (75 min)

There was no significant relationship between alexithymia and cortisol or DHEA alone, but alexithymia did have a negative relationship with the cortisol:DHEA ratio. The negative relationship demonstrates a more favourable endocrine response, as a smaller ratio indicates a more homeostatic HPA axis (Heaney et al., 2013). This result highlights the importance of looking at the ratio between the two hormones. The lack of relationship between alexithymia and cortisol or DHEA alone does contradict expectations for DHEA and previous evidence for cortisol (Hua et al., 2014; Oberbeck et al., 1998; Timary et al., 2008) that these two hormones would be higher in alexithymia individuals. The ratio, however, does provide evidence that alexithymics endocrine response during recovery is better at balancing as illustrated by the significant relationship with the ratios AUCi. The lack of relationship at AUCb means that the ratio at the start of the recovery period did not start any higher or lower in relation to alexithymia. Previous literature has found some evidence of alexithymic individuals having ‘blunted’ physiological responses to stress in terms of skin conductance, HRV etc (Singh et al., 2011). It is possible the ratio may be lower as a result of blunting however as alexithymia has no relationship with cortisol or DHEA individually it is more likely this is just a balanced endocrine response.

Optimism showed no relationships with any of the endocrine markers. Although this is not what was expected, previous literature has been mixed. This study, unlike Nes et al. (2005), did not provide support for the engagement model (Segerstrom et al., 2003). Specifically, optimist’s engagement did not produce a better subsequent performance on the second 3kTT and this engagement did not cause a short term increase in endocrine response. Potentially there was a lack of effort engagement by optimistic individuals which their lack of better subsequent performance by individuals high in optimism supports this along with the lack of correlation between optimism and average HR or RPE during the 2nd 3kTT. This may be because the laboratory study did not create an environment that optimists placed performance as a high priority goal worth engaging effort in. As outlined by the lack of relationship between optimism and subsequent performance in line with previous literature optimists may not engage or transfer resources if they do not place high priority on that goal or outcome (Geers et al., 2009). A lack of priority may be why there is no influence of optimism on subsequent performance on the second 3kTT or endocrine markers.

Alexithymia had a positive relationship with all hypothesised recovery markers across; faster subsequent performance, higher perceptual recovery and a lower cortisol:DHEA ratio in the recovery period between the two 3kTT. The faster subsequent performance provides evidence for better overall recovery and the ability to perform subsequently the more alexithymic an individual. In addition, this better subsequent performance does not appear to come at a perceptual or endocrine cost. When transferring these results to acute training sessions it demonstrates the potential importance of structure and planning in training for athletes high in trait alexithymia to help them produce there bets performance.

Optimism had no relationship with any of the recovery markers hypothesised contradicting all the hypothesises. The lack of relationship may be explained by a lack of engagement due to low priority based on the laboratory experiment by optimists results may differ in an applied setting where it is clearly a high priority goal for individuals. A potential applied finding from this study is the need to ask optimists about recovery at that moment rather than expected recovery which may help to eliminate positive bias giving a non-biased perceived recovery for individuals higher in optimism.

2.6.0.4 Second Post-exercise Recovery Period (50 min)

The hypothesises for the recovery period after the second 3kTT were the same as those hypothesised for the recovery period between exercise bouts, with both alexithymia and optimism expected to have a positive relationship with post-exercise recovery following the second 3kTT. The relationships were not evident with neither the alexithymia nor optimism hypotheses supported by the findings over the second recovery period.

There was no significant relationship between alexithymia and perceived recovery during the recovery period that followed the second exercise bout. There was however a significant positive relationship between alexithymia and cortisol 30 minutes after the second exercise bout. This pattern is seemingly different for individuals who are higher in alexithymia during the 50-minute recovery period that followed the second pre-loaded exercise bout in comparison to the pattern of the same individuals during the 75 min recovery period between the first and second exercise bouts. The situation is different once they finish the second pre-loaded exercise bout because there is no longer another exercise bout to focus on. Hence, thoughts may turn back to general life and general training which would be expected to be stressful for alexithymic individuals (Terock et al., 2020). The change in structure is potentially why the results are different for the recovery period after the second exercise bout. Alexithymia has no relationship with perceived recovery following the second 3kTT. This null finding does provide further evidence for the potential interplay of structure with alexithymia and perceived recovery. There is no further exercise to prepare for/recover for in the second recovery period and this lack of another exercise bout may be why there is no relationship between alexithymia and perceived recovery during this period. While there was a positive relationship between alexithymia and cortisol 30 minutes after the second exercise bout, there was no relationship between alexithymia and DHEA or the cortisol:DHEA ratio.

There were no significant relationships for optimism with perceived recovery or endocrine response in the recovery period after the second exercise bout. From a perceptual point of view, the lack of relationship could again be because of the lack of expectation in how the PRS was asked e.g it asks participants how recovered they feel from the previous exercise bout not if they expect to recover by the next, therefore removing opportunity to evaluate future expectation normally expected by optimists (Carver & Scheier, 2014). Again it is suspected individuals high in optimism because they are being asked how recovered they feel at a moment in time in respect to the last exercise bout, as opposed to whether they expect that they will recover in time for their next training session. The lack of relationship between optimism and endocrine response in the second recovery period could be because of the lack of relationship between optimism and effort engagement. Optimism had no relationship perceptually (RPE) nor physiologically (HR) on average over the 3kTT's show in this study suggesting optimists did not increase there effort.

2.6.1 Limitations

The current study was designed to investigate the relationships between personality and acute post-exercise recovery markers in a very structured and controlled laboratory-based setting. This setting has allowed a good level of control. While insightful, the acute nature of the current study design does limit the ability to interpret what may happen across a more extended recovery time frame, and as such results should only be interpreted in terms of short-term acute recovery. Secondly, the controlled structured environment with a more artificial type of performance outcome in a laboratory-based study means that results may not transfer into a real-world environment where there is less control and successful performance might be more meaningful. The artificial performance climate however had plenty of incentive with prize money on offer hopefully negating some of these considerations.

A way to further control for the laboratory setting would be to measure the task-related stress and importance for each participant. The measurement of task stress would allow further investigation into the perception of how stressful individuals found the task and task importance would allow investigators to control for each participant's perceived importance of the laboratory task.

There is no guarantee that participants gave maximal effort on the first 3k race; a possible addition to try and ensure this result would be to award prizes for the first 3k as well as the second. The majority of participants performed worse in the second race in comparison to the first so participants had tried hard on the first 3k and because of the 80% 10-minute preload there is only so much pacing individuals could do, but again this performance may not have been maximal in comparison to the second 3km trial. The ability to try more or less hard however on the first 3k is potentially limiting. Participants may have strategically allocated resources to do better on the second 3k despite the instructions to try their best and to achieve 80% preload. Some individuals will have been able to do this better than others however, this is in essence part of the design of this study and as such the 1st time trial is controlled for in the analysis to attempt to reduce the influence of this limitation.

2.6.2 Future Directions

It is acknowledged that the current findings can only be interpreted for an acute laboratory setting. In the future it would be of interest to investigate similar recovery markers both longitudinally and in an applied setting to see if the findings from the acute laboratory setting are consistent under different settings, such as before and after a race, or during a training period. Longitudinal studies are becoming more accessible for investigating endocrine function through the use of hair cortisol and the now very easy ability to remotely ask questionnaire data allowing investigation of longitudinal perceptual recovery.

2.6.3 Conclusion

In conclusion, alexithymia from the markers of recovery measured appears to be beneficial towards recovery between exercise bouts. Namely alexithymia had a positive influence on PRS in the 75 minutes recovery between exercise and a negative influence on cortisol:DHEA ratio. Both measures are indicative of better recovery. Alexithymia also had a negative relationship with subsequent performance again indicating better recovery. Alexithymia had a less conclusive influence on recovery after the second exercise bout. Alexithymia did not influence PRS, or cortisol:DHEA ratio but did have a positive relationship with cortisol concentrations alone which would be indicative of worse recovery. Optimism did not affect any of the measured markers of recovery appearing to not affect post-exercise recovery either between the two exercise bouts or after the second exercise bout. Future research could investigate the influence of alexithymia and optimism in longitudinal settings.

3 The influence of Alexithymia and Optimism separately on markers of recovery, stress and well-being during a three-month training period.

3.1 Introduction

Effective post-exercise recovery is essential for athletes if they are to retain appropriate standards of performance in training and competition. While acute recovery from exercise is a fundamental component of the training process, it is equally important that post-exercise recovery and training are well balanced over chronic periods (Carey et al., 2017; Saw et al., 2016). The maintenance of a good balance between training and post-exercise recovery is important to help avoid negative outcomes such as burnout, overtraining, injury or illness (Drew & Finch, 2016; Jones et al., 2016; Kellmann et al., 2018).

Exercise is known to cause acute physiological and psychological disturbances (Harber & Sutton, 1984; Scully et al., 1998). Arguably, when assessing the balance between exercise training and post-exercise recovery throughout chronic training periods, a more expansive appraisal of the athlete is also necessary (Kellmann et al., 2018). Specifically, in such situations, it is also important to obtain a holistic evaluation of the athlete by capturing the daily life factors that may also impact post-exercise recovery such as stress and well-being (Saw et al., 2016). Understanding such factors is potentially even more important in amateur athletes due to the demands of balancing a job, personal responsibilities in the home, and sport participation (MacCosham et al., 2015; Santos, 2013). Capturing a range of factors gives a more comprehensive overview of athlete's recovery from training and increases the likelihood of preventing overtraining or burnout (Gould & Dieffenbach, 2002).

Physiological and perceptual changes caused by acute exercise, particularly exhaustive/high-intensity exercise, may take several hours or days to fully recover from i.e. return to homeostasis (Bishop et al., 2008). As athletes may train most days of the week or multiple times per day athletes may chronically develop perturbations to homeostasis. This imbalance has the potential to alter physiological systems such as the Hypothalamic Pituitary Adrenal (HPA) axis chronically rather than the acute activity seen in Chapter 2. Arguably, the body performs most optimally when it recovers back to a homeostatic state however in reality the body's systems are never completely stable therefore to efficiently balance physiological systems there is inevitably a need to be dynamic. This dynamic stability through change can be described as allostasis (Sterling, 2012; Sterling & Eyer, 1988). First described by Sterling & Eyer (1988) in the cardiovascular literature, Allostasis means "maintaining stability (or homeostasis) through change". Allostasis is the ability to turn adaptive systems on and off again efficiently, helping the body to cope and adapt to the stresses of the world (McEwen, 2004). Chronic imbalances of the HPA axis can lead to allostatic load (McEwen, 1998). Allostatic load can be considered as an inadequate response, a response that is too frequent, or failure of a system to stop responding (McEwen, 1998).

Athletes are potentially at risk of both training and life stress which increases the frequency at which the neuroendocrine system must respond, and individuals may be unable to cope. A marker that can be used as an indicator of allostatic load is cortisol (Juster et al., 2010; Mazgelytė et al., 2019). The inadequate synthesis of cortisol in the HPA axis may lead to individuals' not being prepared for exercise, putting them at potential risk of injury. Excessive synthesis of cortisol, or failure for cortisol's negative feedback loop to work so cortisol keeps synthesising will mean the body is potentially in a catabolic state for longer (Hackney et al., 2008; Lee et al., 2017). It is possible this will make recovery more difficult (Lee et al., 2017) and it also puts the individual at risk of neurotoxicity as cortisol is neurotoxic (Murialdo et al., 2014). In all three cases over synthesis, under synthesis and failure to stop synthesising, may indicate allostatic load. Allostatic load could then in turn lead to reduced performance (Angeli et al., 2004) and physical and mental health problems associated with excessive allostatic load (Beckie, 2012; Juster et al., 2010).

Traditional methods of HPA axis assessment are designed to measure acute cortisol concentrations and therefore make chronic studies of HPA axis activity difficult as repeated saliva and serum samples beyond several hours are impractical due to participant burden,discomfort,dry mouth (saliva) and invasive nature (serum) of sampling (Wright et al., 2015). Possible measures of chronic cortisol are cortisol awakening response (CAR) and hair cortisol. While CAR is considered to be an indirect measure of the chronic cortisol response (Fries et al., 2009) and is moderately associated with alterations in longer term stress, hair cortisol has the potential to directly measure long term hair cortisol concentration (Sabbah et al., 2018). In more recent years there has been the development of hair samples to determine chronic concentrations of cortisol in humans with one cm of hair approximately representing one month of cortisol accumulation (Wennig, 2000). The majority of this work has been done in clinical populations (Koumantarou Malisiova et al., 2021; Russell et al., 2012; Stalder & Kirschbaum, 2012; Staufenbiel et al., 2013), with only three studies investigating hair cortisol in exercising populations (Boesch et al., 2015; Gifford et al., 2019; Skoluda et al., 2012). Two of the studies found a higher cortisol concentration in trained athletes and military trainees in comparison to sedentary individuals (Gifford et al., 2019; Skoluda et al., 2012) and one found no relationship between training and hair cortisol in military training (Boesch et al., 2015). These studies provide initial evidence that exercise training may cause an increase in hair cortisol concentrations.

As with an acute setting (Cook & Beaven, 2013; Laurent et al., 2011; Sikorski et al., 2013), it has also been demostrated that exercise will cause changes to perceptual markers of recovery in a longitudinal setting (Sansone et al., 2020; Sawczuk et al., 2018). Individual perceptions of both exercise training and the recovery from it will be different over time. This may depend on individuals' motivation to exercise, and the emotions individuals attach to exercise and recovery from it (Hamann & Canli, 2004; Judge & Ilies, 2002). In addition to exercise and recovery specific perceptions, when investigating exercise recovery longitudinally it is important to also factor in individual perceptions of wider life outside of exercise training as this may have a bearing on recovery. Perceived stress and wellbeing are two factors to consider as both have the potential to exacerbate or reduce allostatic load (Christensen et al., 2019; Mauss & Jarczok, 2021), which will then potentially affect physiological recovery as well.

Further complexity is added to the post-exercise recovery process in that, on an individual level, differing characteristics may alter the trajectory of common markers of post-exercise recovery, particularly over chronic training periods. The way that characteristics may alter markers of post-exercise recovery over chronic periods of training is however less well explored than the trajectory of the markers themselves. Individuals will inevitably recover differently due to their individualcharacteristics, however, currently, recovery studies tend to adopt a "one size fits all approach" with little consideration of individual personal characteristics (Kellmann et al., 2018). In this regard, one relevant characteristic that has surprisingly received no attention in relation to chronic post-exercise recovery is personality. Personality is known to affect performance both outside and within an exercise/sporting domain (Allen et al., 2013; Barrick et al., 2001; Vealey, 2002). It is also known that personality affects how individuals perceive the world around them (Funder, 2007). Given the strong link between exercise training and post-exercise recovery, it is therefore plausible that personality may affect how individuals recover from training physically and perceptually over chronic periods. It is also possible that because personality can affect how individuals interact with the world around them, and the various stresses these bring that personality will chronically affect perceptions of general well-being (Friedman & Kern, 2014) and general stress (Roohafza et al., 2016) which may have a knock-on effect to exercise training recovery.

Two personality traits with the potential to independently affect markers of recovery are Alexithymia[3] and Optimism.[4] Alexithymia means literally in Latin, without ("a") words ("lexus") for emotions ("thymos") whereas dispositional Optimism is a relatively stable and generalised trait of expecting good outcomes throughout life (Scheier & Carver, 2018). These traits have relationships with health, wellbeing and stress (Kojima, 2012; Lumley et al., 2008, 1996; Ricciardi et al., 2015; Terock et al., 2020) that are likely to also impact longitudinal training and recovery from it. These traits also have independent relationships with both the perceptual and physiological markers such as emotions, cortisol, immune markers, perceived stress before adding the layer of post-exercise recovery (Luminet & Zamariola, 2018; Moriguchi & Komaki, 2013; Nes & Segerstrom, 2006; Panayiotou et al., 2018; Pérez et al., 2021; Scheier & Carver, 2018).

Alexithymia and chronic cortisol have been investigated within clinical (Cascino et al., 2020) and healthy populations (Härtwig et al., 2013). In terms of CAR, healthy alexithymic individuals have been shown to have a lower CAR (Härtwig et al., 2013). The only evidence of alexithymia and hair cortisol analysis took place within

[3]Alexithymic, and high in alexithymia are used throughout this chapter, this refers to individuals who score highly on the respective self-report measure (TAS-20) and are not reference to clinical levels. Additionally, throughout this chapter we conceptualised alexithymia as a stable personality trait that does not change across time, and where an individuals' level of a particular trait can be placed on a continuum from very low to very high.

[4]Optimistic and high in optimism are also used throughout this chapter this refers to individuals who score highly on the respective self-report measure (LOT-R), this is a dispositional optimism measure investigating optimism as a stable trait. Additionally, throughout this chapter we conceptualised optimism as a stable personality trait that does not change across time, and where an individuals' level of a particular trait can be placed on a continuum from very low to very high.

pregnant women where individuals higher in alexithymia had higher hair cortisol concentrations (Kajanoja et al., 2020). Despite the lack of direct investigation between alexithymia and chronic cortisol, several explanations have been offered as to why individuals high in alexithymia may have a different chronic stress response, which converges on alexithymics' struggles with emotion and its regulation.

Alexithymics' may be using their sporting training to help regulate emotion (Roberts & Woodman, 2017). Exercise training causes physiological sensations (Swart et al., 2012) and can help to regulate anxiety (Asmundson et al., 2013). The ability to feel sensations physiologically and regulate anxiety through exercise may, for alexithymic individuals, mean a greater draw to and the need to train harder (Allegre et al., 2007) potentially also becoming addicted to exercise (Manfredi & Gambarini, 2015). There is some anecdotal correlational evidence of needing to train harder in swimmers where individuals higher in alexithymia trained at higher intensities (Allegre et al., 2007), however, it is an area that has very little existing literature.

Alexithymia by its nature may often lead to confusion over how to identify and describe perceptions due to difficulties with emotions. Alexithymics' use of stimuli and the potential use of exercise to regulate emotion (Roberts & Woodman, 2015, 2017) has the potential to alter perceived recovery longitudinally. There is little investigation into alexithymic perception longitudinally outside of clinical populations. There has been an investigation into alexithymic athletes both active and retired, and their relationship with various psychological well-being factors. These investigations found, in both active and retired players, that alexithymia was associated with higher self-reported depression, anxiety, stress, and insomnia, and lower self-reported satisfaction with life (Aston, 2018). This research was only within male athletes but indicates alexithymic individuals' tendency to score highly in the perception of negative emotions/feelings and low on more positive emotions/feelings.

In addition, to scoring highly on negative emotions and low on positive emotions, alexithymia is linked to somatisation with alexithymic individuals focusing on somatic rather than cognitive issues (De Gucht & Heiser, 2003; Mattila et al., 2008). Alexithymic individuals are also known to comparatively over-react to minor stress and under-respond in their perceptions of incremental stress (Kohn et al., 1994), potentially tied to longitudinal continuous hassles in daily life. It is also known alexithymic individuals in a laboratory setting overreact to background levels of stress but under respond to experimentally manipulated stress (Papciak et al., 1985). In addition, alexithymia has been investigated with burnout, being positively related as demonstrated in occupational settings (Iorga et al., 2016; Katsifaraki, 2013; Mattila et al., 2007) and conceptualised in sport settings (Amemiya & Sakairi, 2018). The more alexithymic an individual the more likely they are to experience symptoms of burnout (Mattila et al., 2007; Popa-Velea et al., 2017). Although there is no research on alexithymia and perceived recovery from exercise training, due to alexithymia's link to somatisation and negative emotions, it may be expected that longitudinally alexithymic individuals will not perceive they are well recovered from exercise.

Similar to alexithymia, there has been minimal research into the association between optimism and hair cortisol. Theoretically, optimism should be inversely related to hair cortisol concentrations due to its well-established links with lower perceived stress, greater coping and better health. This rationale has been supported in adolescents (Milam et al., 2014) but not in older adults (Feller et al., 2014). In adolescent studies, dispositional optimism and hair cortisol have a significant inverse relationship, even when controlling for perceived stress (Milam et al., 2014). However, in studies in older adults optimism has been shown to be unrelated to hair cortisol concentrations (Feller et al., 2014).

Optimism has been investigated within the area of exercise training slightly more than alexithymia. A key study that covers optimism and exercise is Kavussanu & McAuley (1995) who found that highly active exercisers were significantly more optimistic than their inactive/low activity counterparts. Optimism is associated with good adherence to tasks as well as problem-focused coping (Nes & Segerstrom, 2006). The crux of 'r colorize("optimists"',"red")' motivation is the belief that what they are doing is expected to be beneficial and positive. Providing that optimists expect exercise training to be beneficial it would be expected that optimists will engage and continue to engage in exercise training, as optimists are known to engage well with important goals and persist in achieving them (Geers et al., 2009). Perception is very tightly woven with optimism, particularly regarding how an individual high in optimism will have positive perceptions about their actions or an upcoming event (Gallagher et al., 2013). Optimism and perceptions of exercise recovery have not been investigated; however, optimism and burnout is an area which has received attention. Optimism is negatively related to both perceived stress (Pathak & Lata, 2019) and burnout across a range of areas including academia (Barkhuizen et al., 2014), business (Hayes & Weathington, 2010), healthcare (Cooper et al., 2016) and sport

(Berengüí et al., 2013; Chen et al., 2008). It, therefore, seems reasonable to suggest that optimism will have a positive relationship with exercise recovery in that the more optimistic an individual the more recovered they will feel.

With these issues in mind, the primary aim of this study was to investigate the effect of personality on chronic exercise recovery over a three-month training period. Recovery was assessed by hair cortisol concentrations and chronic perceptual recovery, within a regularly training sporting student population. The secondary aim was to investigate the effect of alexithymia and optimism on chronic perceptions of well-being and stress. We expected both alexithymia and optimism to independently affect chronic perceptual recovery from training and hair cortisol and expected that these two traits would independently affect perceptions of stress and well-being. The first hypothesis was that alexithymia would be associated with poorer longitudinal recovery indicated by a positive relationship between alexithymia and hair cortisol concentrations, and a negative relationship with perceived recovery scores. The second hypothesis for this study was that optimism would be associated with better longitudinal recovery as indicated by a negative relationship between optimism and hair cortisol concentrations, and a positive relationship with perceived recovery scores.

3.2 Method

3.2.1 Participants

The study received Bangor University ethical approval that follows the Helsinki declaration and all participants provided online informed consent before participating. 110 participants were recruited among university students; participants were excluded from the final analyses if they did not provide the second hair sample (n = 20) or did not regularly participate in sport (n = 11). In total, the data from 79 participants (n = 26 male and 53 female) were included in the final analysis (Figure 3.2). Participant age ranged between 18–35 yrs (*M*=22.56 *SD*=3.57) and had a mean BMI of 23.45(*SD*=3.61). Participants took part in 28 different sports, the most common sport amongst participants was hockey n=22 followed by climbing n=8. Across the range of sports 46% of participants took part in a team sport rather than an individual sport(46% team, 41% individual,13% missing data) ,and across both the team and individual sports 81% of participants were competing in their first choice sport.

3.2.2 Study Design

The study used an observational design with a single group to investigate the influence of alexithymia and optimism on hair cortisol, stress, wellbeing and exercise recovery. The data collection period occurred between October 2019 to January 2020. The study involved two visits to the laboratory separated by three months to the laboratory: Visit 1 consisted of collecting demographic information online using QualtricsXM (age, weight, height, sex, sport), Personality questionnaires and collection of a hair sample which was used to determine the stability of hair cortisol across time. A second hair sample was collected three months later at the second laboratory visit (Visit 2). The second hair sample was used in the main analyses as the cortisol concentration in the second hair sample matches the same time period for which the questionnaires were asked. Between the two laboratory visits, participants completed a weekly online monitoring questionnaire which collected data about training hours, Rating of Perceived Exertion (RPE; Borg (1982)) and contained the Perceived Recovery Status Scale (PRS scale; Laurent et al. (2011)), the Perceived Stress Scale (PSS-4; Warttig et al. (2013)) and the 5-item World Health Organization Well-Being Index (WHO-5; World Health Organisation (1998)).

Figure 3.1: Study schematic of two labratory visits and weekly questionaires: Visit 1 Demographics, and Personality dsata were collected from particpants as well as a hair sample not used in the main analysis. Weekly Online questionaire could be completed on mobile or laptop. Visit 2 collection of hair sample used in main analysis and hair demographics questionaire

3.2.3 Procedures

3.2.3.1 Hair Cortisol Collection

Both samples were collected in the laboratory by trained researchers with 98.4(+/-5.9) days on average between samples. The hair samples were taken from seated participants with multiple smaller samples taken from the posterior vertex. As hair grows at approximately one cm per month on average (Wennig, 2000), a hair length of three cm was collected. This was weighed at the point of collection (>40mg) to ensure an adequate hair sample was collected for biochemical analysis. The collected hair sample was then wrapped in tin foil and placed inside an envelope; this was stored in a locked filing cabinet at room temperature until processing.

3.2.3.2 Hair Processing (Cortisol Extraction)

Biochemical analysis of hair samples was based on previous methods (Kirschbaum et al., 2009; Meyer et al., 2014; Skoluda et al., 2012). In brief, samples were washed twice in 5 ml of isopropanol for 3 min at 30 rpm on a rotator (PTR-60 Multi-Rotator, Grant Instruments, Cambridge, UK), and then left to dry for 48–54 h in a fume cupboard out of direct sunlight. Dried hair samples were then ground for 2 min at 25 Hz by a ball mill (MM400 Mixer Mill, Retsch, Haan, Germany) and 40 mg of the ground hair was added to an Eppendorf tube. Cortisol was extracted from the hair by adding 1.2 ml of methanol to the Eppendorf and incubating for 24 h under constant 100 rpm inversion on the rotator. After each Eppendorf was vortexed and centrifuged at 14,000 rpm for 1 min and then 0.8 ml of the supernatant was transferred into a 2 ml Eppendorf and evaporated (Centrivap, Labconco, Kansas City, USA). Samples were then reconstituted with 80 µl of PBS, vortexed, and frozen at -80°C.

3.2.3.3 Questionaires and Scales

Questionnaires and scales were distributed and data was collected using QualtricsXM. QualtricXM is an online platform that was used for our online data collection. QualtricsXM is frequently used in scientific research as a platform to collect questionnaire data when no direct contact is required with the participant (Devlin, 2020; Machado, 2012). It was used in this study for all questionnaires allowing the completion of a three month study without needing to have a laboratory-based visit. Each week participants received an e-mail with a link to the weekly online monitoring questionnaire. If this weekly online monitoring questionnaire was not completed, participants were sent a further reminder e-mail containing the link. Demographic and personality questionnaires were complete during the first laboratory visit again through Qualtrics. The weekly online monitoring questionnaire was prefaced with the following text, "Please take a few seconds to think back over the last week of training. Think about where you spent most of the time training, who you trained with, and the most memorable session of the week. You may require your training diary to help recall the week.".

3.2.4 Measures

3.2.4.1 Questionnaires and Scales

Alexithymia and optimism, perceived recovery, perceived stress and perceived well-being were completed electronically online using Qualtrics. Alexithymia was measured using the Toronto Alexithymia Scale (TAS) -20 (TAS-20; Bagby et al. (1994)) and optimism using the Life Orientation Test-Revised (LOT-R; Scheier et al. (1994)). Perceived recovery was measured using the PRS Scale (Laurent et al., 2011), perceived stress using a brief version of the PSS-4 (Warttig et al., 2013) and well-being using the WHO-5 (World Health Organisation, 1998).

3.2.4.1.1 Personality

The TAS-20 (Bagby et al., 1994) was used to measure alexithymia. The TAS-20 is comprised of 20 items to assess the alexithymia construct through three main constructs: Difficulty identifying feelings (e.g., I am often confused about what emotion I am feeling); Difficulty describing feelings (e.g., It is difficult for me to find the right words for my feelings); Externally oriented thoughts (e.g., I prefer to analyse my problems rather than just describe them). Items are rated on a five-point likert scale ranging from 1 (Strongly disagree) to 5 (Strongly agree). A total alexithymia score is calculated by combining the three sub-scale scores (high scores equate to high alexithymia). Parker et al. (2003) reported internal reliability coefficients ranging from =0.73 to =0.84 for the total score.

Optimism was measured using the LOT-R, (Scheier et al., 1994). The LOT-R consists of 10-items each of which had a 5-point Likert scale from 1-I disagree a lot, to, 5- I agree a lot. The LOT-R shows internal consistency =.78 ,(Cronbach alpha) and a test-retest reliability (r=.68) over a four-week interval (Czech et al., 2002).

3.2.4.1.2 Perceived Recovery Status Scale

The PRS scale is a 0–10 , scalar representation of varying levels of an individual's PRS, (Laurent et al., 2011). The PRS scale was completed each week by participants. Each week participants were asked, "Over the past week, how well recovered have you felt?". The scale started at 0 =very poorly recovered to 10 = Very Well Recovered, participants were also able to say they had not trained.

3.2.4.1.3 Perceived Stress Scale

Perceived average weekly stress was measured using a shortened version of the Perceived Stress Scale (Cohen, 1994), the PSS-4 (Warttig et al., 2013). The PSS-4 is a four item Likert scale from 0=Never to 4=Very Often. An example item is "How often have you felt that you were unable to control the important things in your life?". Two items are reverse scored,participants were also being asked to rate these scores according to an average of the last week. The PSS-4 has previously been shown to be a reliable measure, with internal reliability of r=0.60 and α =0.77. The PSS-4 was asked of participants each week with them being asked to rate each item in relation to their perceptions over the previous week.

3.2.4.1.4 Well-Being Index

Perceived well being was measured using the Who-5 (World Health Organisation, 1998). The 5-items are rated on a 0-5 Likert scale with 5=All of the time to 0= At no time. An example item is "I have felt calm and relaxed". Specifically, participants were asked to think about these questions in relation to the whole of the week prior.

3.2.4.2 Training Data

As part of the online weekly monitoring questionnaire athletes were asked about the training hours completed each week and their RPE on average for their weeks' training. The CR-10 RPE scale (Borg, 1982) was used to rate perceived exertion on a 0-10 scale with 0=Rest and 10=Maximal. An average weekly training load was then calculated by multiplying training hours by RPE. Training hours, and RPE was completed each week by participants in which they rated each item in relation to their perceptions over the previous week.

3.2.4.3 Hair Demographics

Along with each hair collection a hair demographics questionnaire was asked of each participant. The demographics questionnaire included average weekly hair washing frequency, if participants used hair products, if they dyed their hair, if they were taking medication, the length of exposure of hair to the weather and whether they partook in an indoor or outdoor sport over the three months prior to the hair collection.

3.3 Analysis

3.3.1 Hair Cortisol Biochemical Analysis

Samples were analysed in duplicate by ELISA (cortisol, Salimetrics, LLC). Intraassay and interassay CV were 8.2% and 8.9%, respectively. Hair cortisol concentrations are reported as picograms per microgram of hair in accordance with previous studies (Meyer et al., 2014). Hair cortisol concentration was calculated as picograms per microgram of hair, following Meyer and colleagues (2014), and using the equation:

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$$F = (A/B) * (C/D) * E * 10{,}000$$

Where: A = µg/dl from assay output; B = weight (in mg) of hair subjected to extraction; C = vol. (in ml) of methanol added to the powdered hair; D = vol. (in ml) of methanol recovered from the extract and subsequently dried down; E = vol. (in ml) of assay buffer used to reconstitute the dried extract; and F = final value of hair CORT concentration in pg/mg.

3.3.2 Statistical Analysis

Analysis was conducted in R Statistical Software (v4.1.2; R Core Team 2021) using stats version 4.0.3 to run linear regression, tables were produced using package kableExtra (Zhu,2021) and figures were produced using the package ggplot2 (Wickham, 2009). Regressions were run using an significance level of 0.05 and effect sizes were calculated using cohens f^2 (Cohen, 1977). Sex, activity level and BMI were used as covariates within the analysis for all models. However, none of the covariates were significant in any of the models therefore the simplest models, without covariates, have been presented throughout the results section. The same approach has also been taken for the hair cortisol analysis where none of the following covariates were significant predictors of hair cortisol concentration; Age, Sex, Training Hours, Training Load, Hair Washing Frequency, Use of Hair products, Exposure of hair to the weather, Indoor or outdoor sport. In the proceeding analyses therefore the simplest linear models with just personality and hair cortisol concentration have been presented for clarity. Any variables measured over time e.g perceived recovery, training hours were averaged over the three month collection period and this value was used in the analysis.

3.4 Results

3.4.1 Population Demographics

Table 3.1: Population Demographics Descriptives

	Overall (N=79)
Age yrs	
Mean (SD)	22.35 (3.19)
Range	18.00 - 36.00
Body Mass Index kg/m^2	
Mean (SD)	23.46 (3.68)
Range	17.96 - 32.89
Sex	
Female	53 (67.1%)
Male	26 (32.9%)
Average Training Hours	
Mean (SD)	6.17 (3.47)
Range	1.86 - 17.27
Average Rating of Percieved Exertion	
Mean (SD)	4.65 (1.55)
Range	0.00 - 7.62
Average Training Load	
Mean (SD)	31.64 (23.30)
Range	0.00 - 119.57
Hair Cortisol Concentration pg/mg (Time 1)	
Mean (SD)	7.83 (5.80)
Range	1.22 - 33.83
Hair Cortisol Concentration pg/mg (Time 2)	
Mean (SD)	7.43 (5.93)
Range	1.14 - 37.42
Alexithymia	
Mean (SD)	53.57 (12.12)
Range	28.00 - 77.00

	Overall (N=79)
Optimism	
Mean (SD)	16.09 (4.29)
Range	7.00 - 24.00

3.4.2 Hair Demographics

Table 3.2: Hair Demographics Descriptives

	Overall (N=79)
Hair Washing Freq	
Mean (SD)	4.17 (2.10)
Range	0.00 - 10.00
Average hours a week spent outside	
Mean (SD)	3.30 (3.09)
Range	0.00 - 18.00
Use of Hair Products	
Missing	25 (31.6%)
No	37 (46.8%)
Yes	17 (21.5%)
Dyed Hair	
Missing	25 (31.6%)
No	35 (44.3%)
Yes	19 (24.1%)
Taking Medication	
Missing	25 (31.6%)
No	45 (57.0%)
Yes	9 (11.4%)
Indoor or Outdoor Sport	
Indoor	29 (36.7%)
Missing	3 (3.8%)
Mix	9 (11.4%)

	Overall (N=79)
Outdoor	38 (48.1%)

A independant samples t-test was also run between hair cortisol and whether indviduals were using contraception or not. The t-test was not significant (N = 50, t = -0.22, p = 0.83) demonstrating there was no signifcant difference in hair cortisol concentration between those not using and those using contraception.

3.4.3 Three Month Average Weekly Training Hours and Load

Average Perceived Recovery from training and average weekly training hours have a significant effect on one another, as average training hours increases , the average perceived recovery from training decreases($R^2 = 0.07$, $F(1, 75) = 5.79$, $p = 0.02$). Average Perceived Recovery from training and average weekly training load do not have a significant effect on one another, as average training load increases , the average perceived recovery from training did not decrease ($R^2 = 0.01$, $F(1, 75) = 0.74$, $p = 0.39$).

3.4.3.1 Alexithymia

Alexithymia had no relationship with average weekly training hours nor average weekly training load, Training hours ($R^2 = 0.01$, $F(1, 75) = 0.81$, $p = 0.37$), Training Load ($R^2 = 0.01$, $F(1, 75) = 1.06$, $p = 0.31$). Alexithymia also had no relationship with RPE ($R^2 = 0.01$, $F(1, 75) = 0.58$, $p = 0.45$).

3.4.3.2 Optimism

Optimism had a significant relationship with average weekly training hours. The more optimistic the individual the more training hours they complete ($R^2 = 0.05$, $F(1, 75) = 3.95$, $p = 0.05$). Optimism on average weekly training hours over the three month period, had a cohen's $f^2 = 0.05$ a small effect size and explains 5% of the variance in the model. Optimism, however had no relationship with training load $R^2 = 0.02$, $F(1, 75) = 1.79$, $p = 0.19$). Optimism also had no relationship with RPE ($R^2 < 0.01$, $F(1, 75) = 0.16$, $p = 0.69$).

3.4.4 Hair Cortisol

For the proceeding analysis, the second hair cortisol concentration was used as this 3-month sample aligned with the time over which the questionnaires were taken. The hair cortisol data were not normally distributed so the data was naturally logged. There were no effects of personality on hair cortisol concentrations this was not changed by the inclusion of the following covariates and none of the covariate were significant predictors of hair cortisol concentration; Age, Sex, Training Hours, Training Load, Hair Washing Frequency, Use of Hair products, Exposure of hair to the weather, Indoor or outdoor sport. In the proceeding analyses therefore the simplest linear models with just personality and hair cortisol concentration have been presented for clarity.

3.4.4.1 Alexithymia

There were no significant affects of alexithymia on hair cortisol ($R^2 = 0$, $F(1, 77) = 0.16$, $p = 0.69$).

3.4.4.2 Optimism

There were also no significant effects of optimism on hair cortisol ($R^2 = 0$, $F(1, 77) = 0.11$, $p = 0.74$).

3.4.5 Three Months Average Weekly Perceived Recovery

For the proceeding analysis again the the simplest model with no covaraites are presented. This is because the covariates of training load and training hours had no effect on percieved recovery when either Alexithymia or Optimism where the independent variables.

3.4.5.1 Alexithymia

Alexithymia had a significant effect on average weekly perceived recovery from training over a three month period ($R^2 = 0.13$, $F(1, 75) = 10.86$, $p = 0.01$). The higher an individuals alexithymia score the smaller their perceived recovery from training on average over the three month period, ($P = 0.01$, Figure 3.2). For the alexithymia, PRS over the three month period model alexithymia had a cohen's $f^2 = 0.05$ a small effect size, explaining 17% of the variance in the model. Alexithymia's relationship with average weekly perceived recovery from training was not changed by the inclusion of training hours as a covariate into the model.

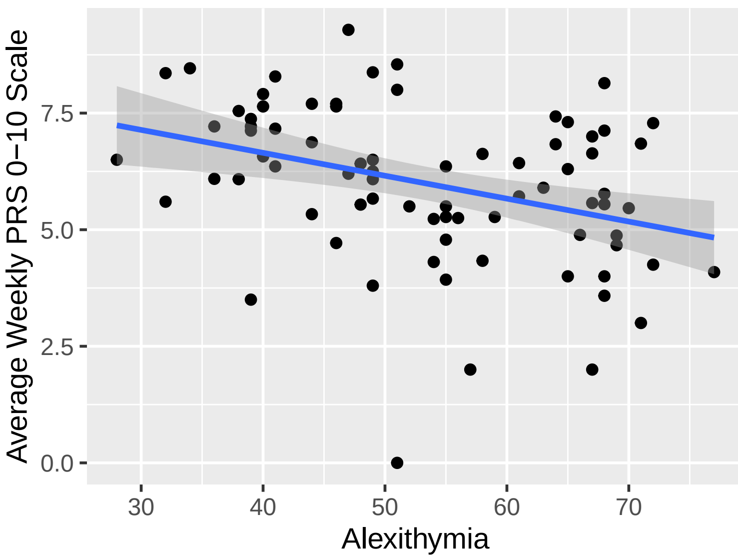

Figure 3.2: Alexithymia and average pecieved recovery over 3 months beta= 0.17,p = 0.01

3.4.5.2 Optimism

Optimism did not have a significant effect on average weekly perceived recovery from training over a three month period $R^2 = 0$, $F(1, 75) = 0.09$, $p = 0.76$). Optimism's relationship with average weekly perceived recovery from training was not changed by the inclusion of training hours as a covariate into the model.

3.4.6 Three Months Average Weekly Perceived Stress & Well-being

Within this study we found alexithymia and optimism has an affect on perceived stress and perceived well-being. No covariates were included in any of the stress or well-being models.

3.4.6.1 Alexithymia

There was a significant relationship between alexithymia and average perceived stress ($R^2 = 0.21$, $F(1, 74) = 19.45$, $p < 0.01$) and alexithymia and perceived well-being ($R^2 = 0.18$, $F(1, 75) = 16.99$, $p < 0.01$). The more alexithymic an individual is the greater the stress perception score and poorer well being perception score on average over a three month period (Figure 3.3).

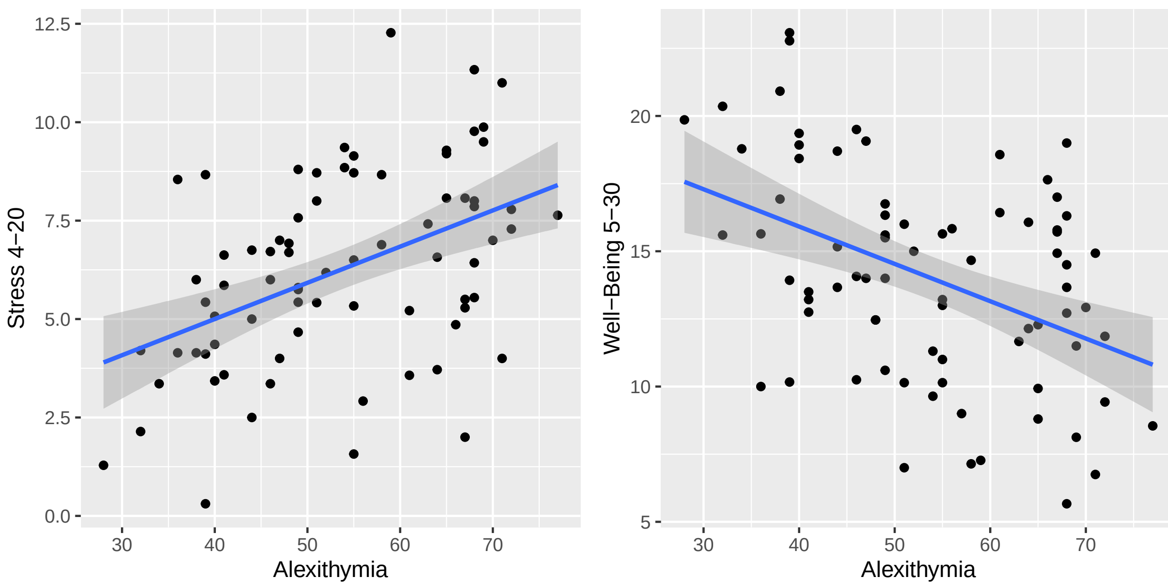

Figure 3.3: Alexithymia and average weekly perceived stress and well-being over three months

For the alexithymia on perceived stress over the three month period model, alexithymia had a Cohen's $f^2 = 0.22$ a medium effect size and explains 18% of the variance in the model. For the alexithymia on perceived well-being over the three month period model alexithymia had a Cohen's $f^2 = 0.22$ a medium effect size and explains 18% of the variance in the model.

3.4.6.2 Optimism

There was a significant relationship between optimism and average perceived stress ($R^2 = 0.44$, $F(1, 74) = 57.13$, $p = <0.01$) and optimism and perceived well-being ($R^2 = 0.25$, $F(1, 75) = 25.58$, $p < 0.01$). The more optimistic an indivdual is the lesser the stress perception score and the greater well being perception score on average over a three month period (Figure 3.4).

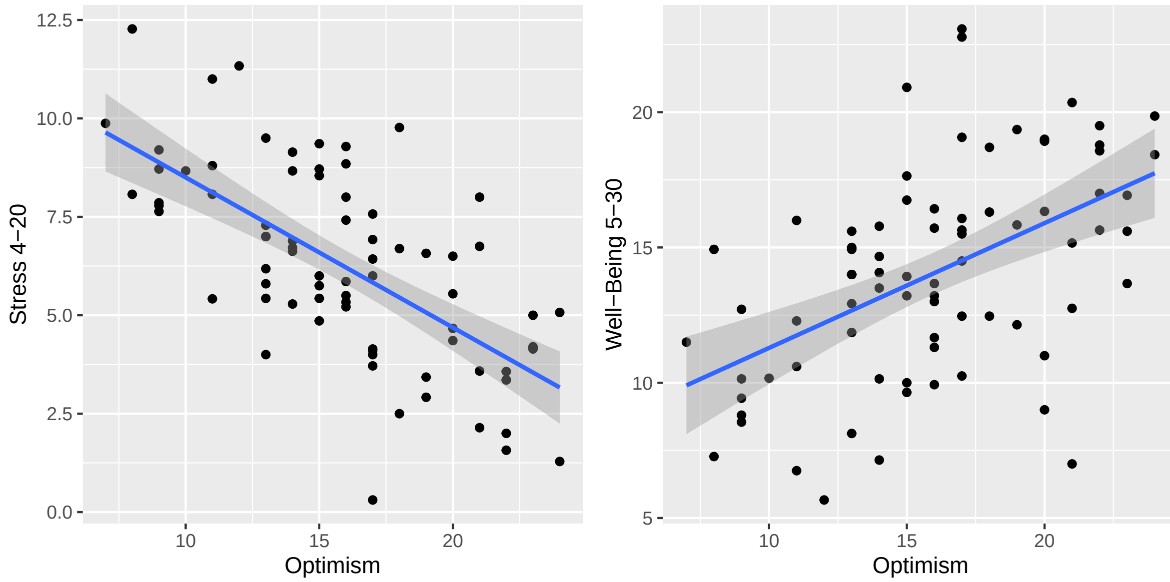

Figure 3.4: Optimism and average weekly perceived stress and well-being over three months

For the optimism on perceived Stress over the three month period model, optimism had a Cohen's $f^2 = 0.69$ a large effect size and explains 41% of the variance in the model.For the optimism on perceived well-being over the three month period model optimism had a Cohen's $f^2 = 0.33$ a medium effect size and explains 25% of the variance in the model.

Table 3.3: Summary of results over the three month training period

	Alexithymia			Optimism		
	r^2	p	Predictor	r^2	p	Predictor
Training Hours	0.01	0.37	NA	0.05	0.05	Postive
Training Load	0.01	0.31	NA	0.02	0.19	NA
RPE	0.01	0.45	NA	<0.01	0.69	N/A
Hair Cortisol Concentration	<0.01	0.69	NA	<0.01	0.74	NA
Percieved Recovery	0.13	<0.01	Negative	<0.01	0.76	NA
Percieved Stress	0.21	<0.01	Positive	0.44	<0.01	Negative
Percieved Well-Being	0.18	<0.01	Negative	0.25	<0.01	Positive

3.5 Discussion

The primary aim of this study was to investigate if alexithymia and optimism separately influenced longitudinal recovery over a 3-month period of exercise training. It was hypothesised that alexithymia would have a negative relationship with recovery from exercise. The alexithymia hypothesis was partially supported. Alexithymia had no relationship with hair cortisol, however, higher levels of alexithymia were associated with poorer perceived recovery from training. The hypotheses relating to optimism and recovery were not supported with no significant relationship with hair cortisol or perceived recovery. In terms of perceptions of stress and well-being, the expectations were met for both alexithymia and optimism. Individuals higher in alexithymia perceived poorer well-being and greater perception of stress, whereas optimism had a positive relationship with well-being and a negative relationship with perceived stress.

3.5.1 Training Hours & Load

There was rationale to expect higher training hours and training load with both personality traits. However, optimism positively predicted training hours and not training load, while alexithymia was not a predictor of either. Alexithymia was expected to have a positive relationship with both training hours and training load due to its previous links to exercise addiction and exercise habituation (Manfredi & Gambarini, 2015). Amongst this sample, however, no such relationship was found. It should be noted that the average RPE across all of the participants wasn't close to maximal at 4.5 (+/- 1.5), the equivalent of between hard and somewhat hard on the verbal indicators. Previous research has shown that optimists engage well with physical activity (Kavussanu & McAuley, 1995; Scheier & Carver, 1992), goals (Geers et al., 2009; Geers, Wellman, Fowler, et al., 2010) and adhering to health programmes (Geers et al., 2009; Geers, Wellman, Fowler, et al., 2010). Therefore it was not unexpected that optimism was positively related to training hours. Optimism had no relationship with training load however the lack of relationship may be because of skew in optimists rating of perceived exertion. Previous research has shown that RPE can be different between personality traits although RPE has not been investigated directly within optimism (Chan et al., 2021; Malik et al., 2020; Masters, 1996). With this in mind, it is possible that session RPE ratings were affected by the optimism itself, hence making the influence of this personality trait on training load more difficult to identify using this measure of training load.

3.5.2 Hair Cortisol

Hair cortisol has previously been shown to be related positively to age, exercise training and contraception. In this study, none of these were predictors of hair cortisol. It is not particularly unexpected that age was not a significant predictor with the present population being all of similar age (22.3 +/-3.2), Dettenborn et al. (2012) showed a significant quadratic relationship with age with the least variation in sample being across the ages of 20-30 the same ages as our age range. Exercise load was also not found to be a predictor of hair cortisol in this study, this null finding is in line with a previous study which found no increase in hair cortisol in male military recruits (Boesch et al., 2015). This does however disagree with two other previous studies investigating exercise and hair cortisol (Gifford et al., 2019; Skoluda et al., 2012) which showed an increase in hair cortisol concentration with increases in exercise, demonstrating this relationship may be more complicated. It is possible that hair cortisol, like salivary cortisol, requires exercise above a certain intensity and/or length for cortisol concentration to show in the hair cortisol (Hill et al., 2008; Luger et al., 1987; VanBruggen et al., 2011). It may be that within our student population the majority were not above a potential threshold whereas the athletes in Skoluda et al. (2012) were, hence the athletic group had higher concentrations of hair cortisol. Finally, contraception was shown as a predictor in Gifford's (2019) study of female military recruits (2019) however again we did not find any relationship between contraception and hair cortisol.

There was no effect of alexithymia on hair cortisol concentrations. This was not in line with the original hypothesis that alexithymia would have a positive relationship with hair cortisol concentration. Alexithymia also had no relationship with training load or training hours so from an exercise viewpoint exercise should have the same effect on hair cortisol concentration regardless of alexithymia. Although as already raised in this study training hours/load were not predictive of hair cortisol concentration. Despite alexithymic individuals not completing high training hours or load it would still be expected that alexithymias' relationship with hair cortisol would be positive. The expected positive relationship is due to previous chronic research demonstrating alexithymic individuals cope poorly with stress and perceived they are more stressed (Fukunishi & Rahe, 1995; Terock et al., 2020). Also, in some acute settings alexithymic individuals have shown elevated cortisol concentrations after an acute stressor (Hua et al., 2014; McCaslin et al., 2006). Furthermore, the relationship between alexithymia and hair cortisol concentrations has been investigated in pregnant women in which alexithymia was related to high hair cortisol concentrations. Overall it is surprising there is no relationship between alexithymia and hair cortisol within this study.

There was no effect of optimism on hair cortisol concentrations. It is however of interest that despite the increase in training hours there was no relationship between optimism and hair cortisol. The relationship between optimism and training hours is of interest because previous hair cortisol studies have demonstrated that regular exercise and increases in exercise load were associated with higher hair cortisol concentrations (Gifford et al., 2019; Skoluda et al., 2012). In this study, however, despite optimists training for longer hours their hair cortisol concentrations were no different to those low in optimism. This null finding may be because of the lack of intensity in the training sessions over the study time period,average RPE 4.5 +/-1.5. Optimism also had no relationship with average RPE.

It has been demonstrated in acute settings that exercise of above 80% $\dot{V}O_2$max is needed to increase salivary cortisol concentrations (Hill et al., 2008; Luger et al., 1987; VanBruggen et al., 2011) and therefore the same intensity may be needed for hair cortisol concentrations to increase. Optimists only had a relationship with training hours and not training load. Training load includes the exertion an individual feels they have put into that training session so given that training load had no relationship with optimism perhaps the perceived intensity of the training sessions was low and therefore explains the lack of relationship between optimism and hair cortisol.

From a chronic post-exercise recovery point of view, it may be that there is a need to look at a ratio akin to something used in Chapter 2 using saliva rather than just one hormone used here to get a better understanding of longitudinal endocrine response to exercise, and recovery from it. It is possible to collect DHEA concentrations within hair (Kintz et al., 1999; Qiao et al., 2017) and therefore it would be worthwhile to examine a cortisol:DHEA ratio chronically in hair as well as acutely through saliva.

3.5.3 Perceived recovery

Alexithymia influenced average weekly perceived recovery from training over three months. As hypothesised, higher levels of alexithymia were associated with poorer perceived recovery. Alexithymia's relationship with poorer perceived recovery supports the theoretical rationale that despite the acute anxiolytic effect of exercise (Roberts & Woodman, 2015; Wipfli et al., 2008), over chronic periods alexithymics do not perceive they are recovered from exercise training. It is also interesting that there was a negative relationship rather than no relationship which could be possible as alexithymic individuals find it difficult to identify and describe emotions (Bagby et al., 1994) which may also mean they find perceiving recovery difficult. This relationship however indicated that alexithymic individuals had a negative perception about their recovery from training over time. This negative perception is potentially because they feel exercise is habitual (Manfredi & Gambarini, 2015) or it may be because of the general stress and anxiety felt by alexithymic individuals in their lives (Berthoz et al., 1999; Terock et al., 2020). It has previously been demonstrated that alexithymic individuals find general life more stressful and additionally cope poorly with stress (Fukunishi & Rahe, 1995; Terock et al., 2020). The combination of generally having higher stress levels and coping poorly with stress means alexithymic individuals are generally feeling more stressed and therefore may find recovering from exercise more difficult, particularly perceptually. Alexithymia also has strong links with anxiety (Berthoz et al., 1999). In combination, generally high levels of perceived stress and anxiety would be expected to make feeling recovered more difficult as information cues associated with perceived recovery are unlikely to be feeling recovered such as feeling relaxed, lower muscle tension and lower heart rate.

It was hypothesised there would be a positive relationship between optimism and perceived recovery however there was no relationship between optimism and perceived recovery. The lack of relationship between optimism and post-exercise recovery may be due to the lack of expectation in the asking of perceived recovery and the lack of a goal. It is well established that optimism revolves around positive expectations of future events (Carver & Scheier, 2014) therefore if expectation is taken away it may be the optimists perceptions do not undertake the positive skew seen around expectation. In this study optimists were not asked to perceive how recovered they expected to be after training but rather how recovered they perceived they were after training. This subtle difference may mean that as no expectation is attached to the perceived recovery optimists do not give the positive bias potentially expected but rather a score reflecting how recovered they perceived themselves in the moment after training. Furthermore, Geers, Wellman, Fowler, et al. (2010) have shown optimist's place effort and engagement behind goals which are a priority. If recovery is not seen as a high priority or is by some optimists and not by others, lack or mixed levels of engagement may again lead to a range of perceived recovery rather than the expected positive relationship.

3.5.4 Perceptions of Stress & Well Being

In terms of perceived weekly general stress and well-being, both alexithymia and optimism showed the expected relationships, alexithymics' perceived more stress and less well-being, optimists the opposite. Individuals' perceptions of general stress and well-being may impact post-exercise recovery across a training period and therefore by measuring the perception of all three it can be speculated that stress and well-being may be impacting perceived recovery. The greater general stress experienced by individuals high in alexithymia may mean this stress impacts their perceived recovery from exercise and allow us to demonstrate the general stress and well-being alexithymic individuals perceive may be part of the mechanism behind alexithymias influence on perceptions of post-exercise recovery negatively. This would then potentially be expected to work in the opposite direction for optimists however the lack of influence on perceived recovery by optimism does not support this within optimism.

The greater an individual's alexithymia score the greater the individuals' perceptions of stress and the smaller the individuals' perceptions of well-being. These findings are unsurprising given alexithymia's ties to depression (Hendryx et al., 1991; Hintikka et al., 2001), anxiety (Berardis et al., 2008; Berthoz et al., 1999; Hendryx et al., 1991), and poor health (Kojima, 2012; Lumley et al., 2008). This finding is also in line with previous research by Terock et al. (2020) demonstrating the strong association between alexithymia and perceived chronic stress and extends the correlation found between the two by Zakiei et al. (2017). With higher scores of alexithymia influencing perception of stress and well-being these scores add support as to why more alexithymic individuals also perceived worse recovery from exercise training on average as these individuals are potentially already stressed from life to start with. Additionally, both alexithymia and perceived stress are strong predictors of burnout (Popa-Velea et al., 2017) and mental health problems (Zakiei et al., 2017) neither of which are likely to be beneficial to post-exercise recovery.

As expected, the higher an individual's optimism score the lower their perception of stress and greater their perceptions of well-being. Again, optimism's relationship with stress and well-being is unsurprising given optimisms links to better health both physically and mentally (Scheier & Carver, 2018, 1992). Optimism's relationship in this study with well- being also agrees with previous research which demonstrated a moderate to strong correlation between optimism and perceived well-being (Dionigi et al., 2020). Optimism was also demonstrated to be a predictor of the perceived well-being (Dionigi et al., 2020). Furthermore, optimism is known to have a negative relationship with perceived stress (Pathak & Lata, 2019) which the results of this study also found. Optimism did not have a relationship with perceived recovery however despite the influence of optimism on perceived stress and well-being which may lead one to expect a positive relationship with perceived recovery. This was however not the case perhaps optimists lower perceived stress and greater perceived well-being is helping to protect against higher concentrations of hair cortisol and a negative relationship with perceived recovery. This influence however is not strong enough to have a positive effect on perceived recovery for optimistic individuals.

3.5.5 Implications

In the applied sporting world, there is potentially a worry about the psychological and physiological effects training may have on an individual and whether there is a physiological and/or psychological cost associated with that training. It is apparent that alexithymia nor optimism does not affect an individual physiologically in terms of chronic cortisol levels over a 3-month training period, however both have an effect on individuals perceived recovery, stress and well-being. As such it would be recommended that coaches working with athletes may be advised to understand how alexithymic or optimistic an athlete is so they are able to support the athlete's individual needs. Unsurprisingly individuals high in alexithymia perceived they are more stressed, and potentially impacts on their perceived recovery from training. A potential positive here for alexithymic individuals is that despite perceptual stress, it does not appear to influence their chronic cortisol concentrations. Optimists on the other hand again unsurprising are generically less stressed but interestingly show no effects for perceived recovery despite training for more hours and generally feeling less stressed. Relating to the applied world of training for sports, individuals high in optimism may find it easier to put in more training hours, whereas scores of alexithymia does not influence training hours. As such coaches who are aware of the trait level of optimism and alexithymia in their athletes will be able to better support them in the hours they train. Also, perhaps coaches can then understand the likelihood of their athlete feeling greater or worse perceptions of well-being and stress.

3.5.6 Limitations

This study was deliberately designed to be completed in the field, as such there was limited control over how participants completed questionnaires which were given to them on a weekly basis. It is therefore possible that due to this limited control that participants completed the questionnaire with more or less care or attention to detail. Therefore the potential for misunderstanding is greater than questionnaires completed in a laboratory study for example where a researcher is present to ask for help.Within this study's sample participants took part in a wide range of sports and activities, thus intensity and frequency of exercise were different across participants. These factors become difficult to control statistically even with a training load and is, therefore, a limitation of this study as it has participants who take part in a broad range of sports. This study is one of the first to investigate hair cortisol in a sporting population. As such it was only possible to investigate a single hormone due to the time constraints of creating and implementing a new biochemical technique and process. Only analysing a single hormone does however mean only part of the HPA axis is investigated in this study unlike Chapter 2 where saliva allowed us to look at a cortisol:DHEA ratio. As this study was unable to look at the ratio it means conclusions can only really be drawn about cortisol and implications for the HPA axis should be approached with caution due to only one hormone being assessed.

3.5.7 Future Directions

In the future, it would be of interest to look at the cortisol:DHEA ratio chronically within hair. Such an approach may give a better indication as to how the HPA axis is functioning chronically. Another direction would be to look at training in further depth. There is now greater accessibility to training data through tracking apps such as Strava among others. It may be possible to look longitudinally at training with more depth allowing investigations to look more precisely at training load, training frequency and even physiological markers such as heart rate recovery chronically. A further direction would be to investigate the above in relation to competition as opposed to training to see if alexithymia and optimisms influence on recovery changes in relation to competitive event/s.

3.5.8 Conclusion

Alexithymia had a negative relationship with average weekly perceived recovery from exercise training. Alexithymic individuals felt less recovered, however, from a chronic cortisol perspective, individuals' scores of alexithymia had no influence on hair cortisol concentrations. Alexithymia did not influence training hours nor load but did have a positive relationship with perceived stress (more alexithymic, more stress) and a negative relationship with perceived well-being (more alexithymic, worse well-being) during the three month training period. Optimism on the other hand did not influence chronic exercise recovery either perceptually or in terms of chronic cortisol concentration over the three month training period. The lack of influence of optimism on recovery is particularly interesting considering optimism did have a positive influence on training hours and perceived well-being and negative relationship with perceived stress over the three month training period. Future research could start to investigate personalities effect on post-exercise recovery in the lead up to and after a competition.

4 The influence of Alexithymia and Optimism separately on perceived post-exercise recovery within an amateur race setting

4.1 Introduction

The build-up to a big athletic event or competition will naturally involve periods of training. When training in preparation for an event, effective recovery from that training is a key feature (Kellmann et al., 2018). Equally important is the way that an individual then recovers from the event itself. The extent to which one feels recovered when training for an event or competition, and in the hours that follow the event or competition, will depend on a variety of factors. For example, the frequency and duration of training, and the intensity of an event. Less is however known about the psychological factors that may influence post-exercise recovery during these periods and in particular, the way that certain personality traits may influence post-exercise recovery during these times.

It has already been shown that exercise causes disturbances, and that these may influence an individual's perceived recovery from exercise (Chapter 2 and 3). Again, a trait with the potential to effect post-exercise recovery when training prior to and event or competition and/or following that event or competition is alexithymia.[5] Alexithymia has been described as the absences of words to express emotions (Roberts & Woodman, 2015). As already established alexithymics struggle to identify and describe feelings and emotions (Luminet & Zamariola, 2018), and individuals high in alexithymia are associated with poorer health (Kojima, 2012), poorer emotion regulation (Luminet & Zamariola, 2018), better sports performance (Lopes et al., 2019) and coping poorly with stressful events (Fukunishi & Rahe, 1995). Alexithymics also perceive themselves generally as more chronically stressed (Terock et al., 2020).

A second trait which again theoretically may affect individuals perceptions of

[5] Alexithymic, and high in alexithymia are used throughout this chapter, this refers to individuals who score highly on the respective self-report measure (TAS-20) and are not reference to clinical levels. Additionally, throughout this chapter we conceptualised alexithymia as a stable personality trait that does not change across time, and where an individuals' level of a particular trait can be placed on a continuum from very low to very high.

post-exercise recovery is Dispositional Optimism.[6] Optimism is a relatively stable and generalised trait that is associated with good outcomes throughout life (Scheier & Carver, 2018). Optimism is related to better coping strategies (Nes & Segerstrom, 2006), better general health (Carver & Scheier, 2014), better engagement with tasks (Geers et al., 2009) and lower perceived stress (Chang, 1998; Friedman et al., 1992). Both alexithymia and optimism are likely to lead to differing perceptions in post-exercise recovery. It is important to note that while both optimistic and alexithymic individuals do have feelings and emotions, alexithymic individuals struggle with the interpretation of these emotions, often finding it easier to describe the physical side of emotions rather than describe the more cognitive side (De Gucht & Heiser, 2003) of the emotion. Optimists however tend to regulate emotions well and most of the time will regulate into a positive mindset (Carver & Scheier, 2014).

Personality is also known to influence the way that individuals perceive the world around them (Blake & Ramsey, 1951). Perception before a race may be different to that after a race as well as the perceived recovery potentially being different after training in comparison to after a race. Exercise recovery is made up of three main components physiology, psychology and emotional response (Laurent et al., 2011) and as such, the perceived recovery status (PRS) scale allows a simple and adaptable measure for both after training and after a race (Laurent et al., 2011; Paul et al., 2019; Sansone et al., 2020; Sikorski et al., 2013). The perceived recovery on average over a training period before a race and after a race itself may also differ depending upon the personality trait of the individual perceiving recovery.

Alexithymia is a trait that may influence perceived recovery both before and after a race due to alexithymias' relationships with anxiety and somatisation. A risk to ego may be created by a sporting performance because performance can go well or not, the risk of a bad performance, therefore, threatens the ego (Roberts & Woodman, 2015, 2017). This risk/threat to the ego of a poor performance increases anxiety before performing which will then decrease during the performance (Fenichel, 1939; Roberts & Woodman, 2015, 2017). In the training building up to a race therefore anxiety may be high amongst alexithymic individuals impacting on the perceived

[6] Optimistic and high in optimism are also used throughout this chapter this refers to individuals who score highly on the respective self-report measure (LOT-R), this is a dispositional optimism measure investigating optimism as a stable trait. Additionally, throughout this chapter we conceptualised optimism as a stable personality trait that does not change across time, and where an individuals' level of a particular trait can be placed on a continuum from very low to very high.

recovery from training. Additionally, alexithymic individuals perceive they are chronically stressed (Terock et al., 2020) which again may have a negative impact on perceived recovery during training for individuals high in alexithymia. Finally, somatising by alexithymic individuals may again have a negative impact on perceived recovery. Somatisation is the manifestation of psychological stress as physical symptoms (Lipowski, 1987). Therefore alexithymic individuals are already likely to have more perceived aches and pain before training (De Gucht & Heiser, 2003), when exercise training is added this may be exacerbated further having a negative impact on individuals perceived recovery after training.

During the build-up to a race alexithymic are likely to have high levels of anxiety and stress (Berthoz et al., 1999; Hendryx et al., 1991; Terock et al., 2020) and following the thoughts of Roberts & Woodman (2015); Roberts & Woodman (2017) the race provides a very good opportunity to regulate the anxiety through the race. As such the anxiety reduction is likely to have a positive effect on mood (Steptoe et al., 1989) which may, in turn, have a positive effect on perceived recovery for individuals high in alexithymia. Depending on the importance and anxiety felt before and then regulation of the anxiety through the race may determine the magnitude of the effect of the anxiety regulation on perceived recovery.

Optimists are also known to generally be positive about the future (Carver & Scheier, 2014) and therefore if this positivity follows into recovery this would have a positive effect on PRS for optimistic individuals. This may be particularly true in the lead up to a race as optimists may expect to be well recovered for the race and also engage in appropriate coping as the race is likely to be a priority goal. Optimists are known to use appropriate coping to deal with the stress in achieving a priority goal (Geers, Wellman, Fowler, et al., 2010; Hanssen et al., 2015). Therefore in the training, before a race optimistic individuals are likely to engage well with appropriate coping mechanisms to help with stress and possibly recovery leading to optimists perceiving they are better recovered. Optimists may also expect to recover well during the training period so that they can do their best in the race. Expectations positive influence in optimists is demonstrated well in optimism and placebo literature where optimism has a positive relationship with the positive placebo response when they expect the placebo to work (review Kern et al., 2020). Therefore over the two week training period in the lead up to the race providing optimists expect to recover from their training a positive effect on perceived recovery with optimists perceiving greater recovery. A final element to add is optimists'relationship with pain. Basten-Günther et al. (2018) systematic review of optimism and the experience of pain provides evidence that optimism is overall negatively related to chronic pain. A possible mechanism behind this is that optimists have a lower pain sensitivity (Goodin & Bulls, 2013). Whilst recovery is not the absence of pain, it is likely a lower feeling of pain will have a positive impact on perceived recovery, therefore if optimists experience less pain this is likely to have a positive influence on perceived recovery, so optimists may perceive they are more recovered.

A race is likely to be a priority goal for all individuals. Individuals high in optimism however are known to engage well with goal setting and engaging with priority goals increasing their effort and therefore optimists may see even greater benefit by the race being a priority goal for them. If it is a priority goal for optimists as well as using appropriate coping in the training before the race, these individuals are also likely to engage more effort to perform well (Roberts & Woodman, 2015). The increase in effort by optimists to achieve a goal has been demonstrated previously by Geers et al. (2009). Geers et al. (2009) demonstrated that optimists engaged more effort when a goal was of high priority. The increase in engagement and effort to perform well in a race (Roberts & Woodman, 2015) may have a detrimental effect on perceived recovery after the race as individuals may have engaged a lot more effort and therefore perceive they are less recovered (Clemente et al., 2019; Ouergui et al., 2020).

The present research will investigate the effect of alexithymia and optimism on post-exercise recovery during the build-up to, and in the period after, an amateur cycling race. The build-up to the race and the race itself is very difficult to simulate in a laboratory and therefore performing a field study will allow us to collect data before and after a real-world scenario giving a better picture of how alexithymia and optimism affect individuals outside of a laboratory setting as seen in Chapter 2. It was hypothesised that alexithymia would have a negative relationship with perception of post-exercise recovery from training in the two weeks prior to a race, but a positive perception of post-exercise recovery after the race.These hypotheses would fall in line with the findings of Chapters 2 and 3. Optimism was hypothesised to have a positive relationship with perception of post-exercise recovery from training in the two weeks prior to the race,but a negative perception of post-exercise recovery after the race, again falling in line with the similar hypotheses proposed in Chapters 3 and 2

4.2 Method

4.2.1 Participants

This study recruited 156 cyclists who were taking part in the one of the hardest amateur bicycle road races. There were both male (136) and female (20) participants between the ages of 20-55 (M = 45.62, SD = 10.41) with height (M = 177.01, SD = 6.71)cm, weight (M = 74.06kg, SD =`r weightSD`) and BMI (M=23.58, SD=3.61).Participants were well trained with an average training duration of M = 155.93 mins (SD=123.99)per week and average training distance of M = 86.74 km (SD = 105.59) per week. The study received Bangor University ethical approval which follows the Declaration of Helsinki and all participants provided online informed consent before participating.

4.2.2 Study Design

The study was a prospective cohort observational study to investigate the affect of personality on perceptions of post-exercise recovery from training in the two weeks prior to the cycling race, and upon going to sleep the same night as the race, with the race having taken place earlier that day. The study was completed entirely online for all participants. Individuals completed three main data collection points with the first data collection point occurring two weeks before the cycling race, the second one-two days before the cycling race, and third one the evening after the cycling Race (asked retrospectively up to two days later). The first data collection two weeks before included the alexithymia and optimism questionnaires. Along with these participants also completed a daily questionnaire throughout the two weeks before the race. The daily questionnaire included rating of perceived exertion (RPE), training hours and the PRS Scale. Two days prior to race participants completed the REST-Q. Participants then completed a questionnaire about race data, post-race PRS scale and RPE retrospectively up to two days after they completed the race.

4.2.3 Procedures

4.2.3.1 Questionnaires

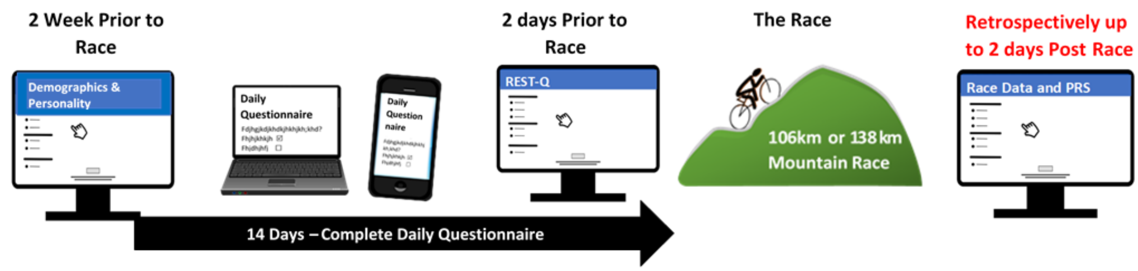

Figure 4.1: Cycle Race Study Design Schematic: Outline of each phase of the studies data collection and the race itself, the questionaire were completed entirely online with reminders to complete them if they had not been completed by particpants.

All questionnaires were completed remotely using QualtricsXM, an online platform. Participants also had the choice of whether to answer the questionaries in Italian or English. QualtricsXM is frequently used in scientific research as a platform to collect questionnaire data when no direct contact is required with the participant (Devlin, 2020; Machado, 2012). Participants received an e-mail with a link to the questionnaire they needed to complete, if this questionnaire was not completed participants were sent an email reminder that it needed completed with another link being sent to their email.

4.2.3.2 Amateur Cycling Race

The amateur cycling race took place in Italy and all participants competed in either the 106km or 138km course of the cycling race. The 106 and 138km courses both cover six mountain passes with the 106km course climbing a total altitude of 3,130m. The 138km course includes a further mountain pass taking the total climbed altitude to 4,320m.

4.2.4 Measures

4.2.4.1 Questionnaires

All participants were given the option to complete questionnaires in either Italian or English. This meant that 88% of participants were able to complete the study in their first language, 97 participants completed the questionnaires in Italian and 59 completed the questionnaires in English. Where possible if a questionnaire had an Italian version this was used, TAS-20, (Craparo et al., 2015), LOT-R (Giannini et al., 2008), REST-Q (Fronso et al., 2013). If a validated Italian version was not available the English questionnaire was translated by a native Italian speaker (PRS, RPE and PSS-4).

4.2.4.1.1 Personality

Alexithymia - Torotono Alexithymia Scale (TAS)-20 (Bagby et al., 1994) with weakest loaded items excluded to total 16 items was used to measure alexithymia (Parker et al., 2003). It has been previously used in sports research when investigating alexithymia in high-risk sports (Cazenave et al., 2007; Woodman et al., 2010). The TAS-20 is comprised of 20 items to assess the alexithymia construct through three main constructs: Difficulty identifying feelings (e.g., I am often confused about what emotion I am feeling); Difficulty describing feelings (e.g., It is difficult for me to find the right words for my feelings); Externally oriented thoughts (e.g., I prefer to analyse my problems rather than just describe them). Items are rated on a five-point Likert scale ranging from 1 (Strongly disagree) to 5 (Strongly agree). A total alexithymia score is calculated by combining the three sub-scale scores (high scores equate to high alexithymia). Parker et al. (2003) reported internal reliability coefficients ranging from =0.73 to =0.84 for the total score. For this study, we reduced the items to 16 items to reduce the number of items participants had to fill out. The four removed items had the lowest factor loadings on Parker et al. (2003) factoral validity of the TAS-20.

Optimism was measured using the Life-Orientated Test-Revised version (LOT-R), (Scheier et al., 1994) but with the four filler questions removed. The LOT-R with filler questions removed consists of 6-items each of which has a 5-point Likert scale from 1-I disagree a lot, to, 5- I agree a lot. For this study, the four filler questions were removed to reduce the number of items participants had to fill out as the questionnaire was part of a larger study. The LOT-R shows internal consistency α=.78 and a test-retest reliability (r=.68) over a four-week interval (Czech et al., 2002).

4.2.4.1.2 Training & Post-Race Perceived Recovery

The PRS Scale developed by Laurent et al. (2011) has been used in previous research (Sansone et al., 2020; Sikorski et al., 2013) and uses a single scaled item to assess the perceived recovery. The PRS scale is a 0–10, scalar representation of varying levels of an individual's level of PRS starting at 0= Not very well recovered to 10=Very well recovered. Perceived recovery was assessed in the daily and post-race data collections. During the daily questionnaires participants were asked to rate how recovered they felt one hour after training and how recovered they felt overall at the end of the day before going to bed. For the post-race data collection participants were asked how recovered from the race they felt upon going to bed on the night after the race, having completed it that day.

4.2.4.1.3 Training & Post-Race Rating of Perceived Exertion

Rating of Perceived exertion (RPE) or sense of effort refers to the conscious sensation of how hard, heavy and strenuous a physical task is. Perception of exertion was recorded with the CR-10 developed by Borg (Borg, 1998). The scale ranges from 0 (no exertion) to 10 (maximal exertion) with participants rating online the following day how hard, heavy and strenuous they found the previous days training. RPE was assessed in the daily and post-race data collections.

4.2.4.1.4 RESTQ-36-R-Sport

The Recovery-Stress Questionnaire for Athletes (RESTQ-36-R-Sport, Nicolas et al. (2019)) is a shorter version of the original 52-item REST-Q Sport (Kellmann & Kallus, 1999). The REST-Q 36-R-Sport includes for general sub- scales general stress (general stress, social stress & fatigue), general recovery (somatic relaxation, general well-being, and sleep quality), sports stress (disturbed breaks, emotional exhaustion, and fitness, injury) and sports recovery (fitness, being in shape, personal accomplishment, and self-efficacy). The REST-Q-36-R-Sport is structurally valid at a two-factor level of stress and recovery (Nicolas et al., 2019), the two-factor structure was chosen for this study so that pre-race stress and recovery could be accounted for. The REST-Q was measured two days, prior to the cycling race.

4.2.4.1.5 Training and Race Load

Average Training load was calculated for athletes training in the two weeks run-up to the race by calculating the averaging daily training load (Training RPE x Training Duration) the averaging this across the two weeks. The calculated training load allowed us to establish participants' average training load for the two weeks before the race. The same calculation was used to establish a 'race' load specifically during the cycling Race (RaceRPE X Racetime) so that exercise load is controlled for in the post-race recovery analysis.

4.2.4.1.6 Anxiety

Anxiety was m easured using a single item 0-5 Likert scale attached to the question How anxious did you feel yesterday before bedtime? The Likert scale was anchored with 0-Not at all Anxious, and 5 extremely anxious. This scale was asked every day during the two-week build-up to the race with an average being calculated and used in analyses. This scale was also asked the day prior to the race and used as a single datapoint.

4.2.5 Statistical Analysis

Linear regression was used to investigate the relationship between alexithymia and average daily perceived post-exercise recovery from training during the two-week training period. Linear regression was also separately used to investigate the relationship between optimism and average daily perceived post-exercise recovery from training during the two-week training period. Analysis was conducted in R Statistical Software (v4.1.2; R Core Team 2021) using stats version 4.0.3 to run linear regression, tables were produced using package kableExtra (Zhu,2021) and figures were produced using the package ggplot2 (Wickham, 2009). Regressions were run using an alpha level of 0.05.

For the regression models, the sample size varied depending on the number of responders who completed daily questionnaires and those who completed the post-race questionnaire (Figure 4.2). For the two-week build-up average PRS regression model, all participants who had completed the daily questionnaire were included $N = 79$. For the post-race regression model, all participants who had completed the post-race questionnaire were included $N = 136$.

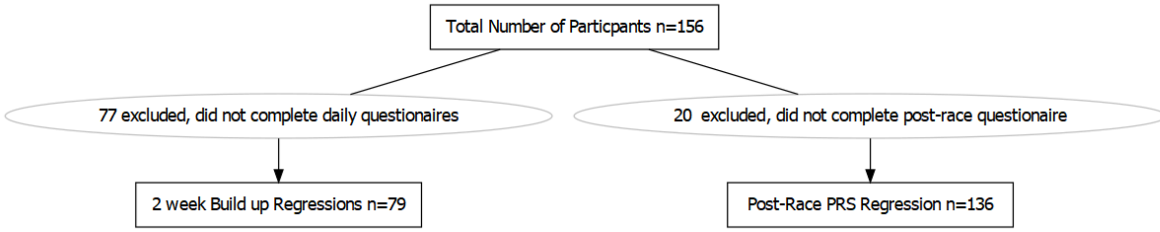

Figure 4.2: Regression Samples. Samples and excluded data for each regression.

4.3 Results

Through the results models are referred to a simple models and covariate models. A simple model refers to a regression model which only includes alexithymia or optimism as the independent variable and the dependent variable with no covariates. A covariate model refers to regression models that contain Alexithymia or Optimism and covariates as well as the dependent variable.

4.3.1 Training Hours, Training Load, RPE and Anxiety

Alexithymia and optimism may influence training load, training hours, training effort (RPE), anxiety in the build up to the race, anxiety before the race, race effort and race load. As such we ran simple regression to check the influence of alexithymia and optimism on load, hours, effort and anxiety.

Table 4.1: Alexithymia and Optimism's influence on Training Load, Training Hours, Anxiety and Effort

	Alexithymia			Optimism		
	r^2	p	Predictor	r^2	p	Predictor
Average Training Load	<0.01	0.57	N/A	<0.01	0.89	N/A
Average Training Hours	<0.01	0.94	N/A	0.01	0.41	N/A
Average RPE	0.01	0.35	N/A	0.01	0.35	N/A
Average Anxiety	0.02	0.11	N/A	<0.01	0.52	N/A
Race Load	0.01	0.32	N/A	0.07	<0.01	Positive
RaceRPE	<0.01	0.86	N/A	0.03	0.04	Positive
Anxiety two days before race	<0.01	0.76	N/A	0.02	0.06	Positive

4.3.2 Longitudinal (2 weeks Prior) PRS and Personality

4.3.2.1 Alexithymia

In the two weeks building up to the race there was no significant effects for alexithymia on average daily PRS score one hour after training, in either the simple ($R^2 < 0.01$, $F(1, 77) = 0.03$, $p = 0.86$) or covariate model (R^2 =0.11, $F(5,73) = 1.78$, $p = 0.13$). The inclusion of training load, Sex,Age and BMI into the model did not change the beta coefficient for alexithymia with only age being a significant predictor of PRS one hour post training two weeks prior to the race. The simple model explained 0.04% of the variance, the entire covariate model explained 10.86% of variance with alexithymia less than 1% of the variance.

Table 4.2: Regression Model Alexithymia including covariates, average one hour post-training percieved recovery

	Estimate	SE	LL	UL	p
(Intercept)	7.86	1.41	5.05	10.66	0.00
Training Load	0.00	0.00	0.00	0.00	0.35
Sex	-0.57	0.44	-1.44	0.31	0.20
Age	-0.03	0.01	-0.06	-0.01	0.01
BMI	0.03	0.03	-0.04	0.10	0.38
Alexithymia	-0.01	0.02	-0.04	0.03	0.68

Note: LL,UL are abbreviations of the lower level and upper level 95% confidence intervals respectively

In the two weeks building up to the race there was no significant effects for alexithymia on average daily overall PRS score , in either the simple (R^2 = 0, F(1, 77) = 0.01, p = 0.93) or covariate model (R^2 =0.02, F(5,73) = 0.28, p = 0.92). The inclusion of training load, Sex,Age and BMI into the model did not change the beta coefficient for alexithymia with only age being a significant predictor of average daily overall PRS score two weeks prior to the cycle race. The alexithymia only simple model explained 0.01% of the variance, the entire covariate model explained 1.9% of variance with alexithymia less than 1% of the variance.

Table 4.3: Regression Model Alexithymia including covariates, average overall daily percieved recovery

	Estimate	SE	LL	UL	p
(Intercept)	7.00	1.67	3.67	10.32	0.00
Training Load	0.00	0.02	-0.04	0.04	0.82
Sex	0.00	0.00	0.00	0.00	0.90
Age	-0.49	0.52	-1.52	0.55	0.35
BMI	-0.01	0.02	-0.04	0.02	0.48
Alexithymia	0.01	0.04	-0.07	0.09	0.78

Note: LL,UL are abbreviations of the lower level and upper level 95% confidence intervals respectively

4.3.2.2 Optimism

In the two weeks building up to the race there was no significant effects for optimism on average daily PRS score one hour after training, in either the simple (R^2 = 0.01, $F(1, 77) = 1.06$, $p = 0.31$) or covariate model (R^2 =0.11, $F(5,73) = 1.88$, $p = 0.11$). The inclusion of training load, Sex,Age and BMI into the model did not change the beta coefficient for optimism with only age being a significant predictor of PRS one hour post training two weeks prior to the cycle race. The simple model explained 1.36% of the variance, the entire covariate model explained 11.41% of variance with optimism less than 1% of the variance.

Table 4.4: Regression Model Optimism including covariates, average one hour post-training Percieved Recovery

	Estimate	SE	LL	UL	p
(Intercept)	7.62	1.14	5.35	9.90	0.00
Training Load	0.00	0.00	0.00	0.00	0.37
Sex	-0.46	0.43	-1.31	0.39	0.29
Age	-0.03	0.01	-0.06	-0.01	0.02
BMI	0.04	0.03	-0.03	0.10	0.31
Optimism	-0.03	0.03	-0.09	0.04	0.43

Note: LL,UL are abbreviations of the lower level and upper level 95% confidence intervals respectively

In the two weeks building up to the race there was no significant effects for optimism on average daily overall PRS score, in either the simple ($R^2 = 0$, $F(1, 77) = 0.21$, $p = 0.65$) or covariate model (R^2 =0.02, $F(5,73) = 0.29$, $p = 0.92$). The inclusion of training load, Sex,Age and BMI into the model did not change the beta coefficient for optimism with only age being a significant predictor of average daily overall PRS score two weeks prior to the race. The optimism only simple model explained 0.27% of the variance, the entire covariate model explained 1.94% of variance with optimism explaining less than 1% of the variance.

Table 4.5: Regression Model Optimism including covariates, average overall daily percieved recovery

	Estimate	SE	LL	UL	p
(Intercept)	6.82	1.36	4.11	9.53	0.00
Training Load	0.00	0.00	0.00	0.00	0.91
Sex	-0.43	0.51	-1.44	0.58	0.40
Age	-0.01	0.02	-0.04	0.02	0.50
BMI	0.01	0.04	-0.07	0.10	0.74
Optimism	-0.01	0.04	-0.09	0.06	0.77

Note: LL,UL are abbreviations of the lower level and upper level 95% confidence intervals respectively

4.3.3 Percieved Recovery after Competition before bedtime

4.3.3.1 Alexithymia

There are no significant effects for alexithymia on post race PRS measured before bedtime in either the simple (R^2 = 0.01, $F(1, 134) = 0.68$, $p = 0.41$) or covariate model (R^2 =0.1, $F(4,100) = 2.81$, $p = 0.03$) , which included Race load, REST-Q as covariates before bedtime. Race Load was the only significant covariate in the model ($p = 0.03$).

Table 4.6: Regression Model Alexithymia including covariates,rercieved recovery upon going to bed after the race

	Estimate	SE	LL	UL	p
(Intercept)	5.89	1.84	2.25	9.53	0.00
Race Load	0.00	0.00	0.00	0.00	0.00
REST-Q Recovery	-0.01	0.10	-0.21	0.19	0.91
REST-Q Stress	-0.12	0.16	-0.44	0.20	0.46
Alexithymia	0.04	0.03	-0.01	0.09	0.15

Note: LL,UL are abbreviations of the lower level and upper level 95% confidence intervals respectively

4.3.3.2 Optimism

There are no significant effects for optimism on post race PRS measured upon going to bed in either the simple model ($R^2 = 0$, $F(1, 134) = 0.47$, $p = 0.49$) or covariate model (R^2 =0.08, F(4,100) = 2.3, p = 0.06) , which included race load, REST-Q as covariates. Race load was the only significant covariate in the model (p = 0.02).

Table 4.7: Regression Model Optimism including covariates,percieved recovery upon going to bed after the race

	Estimate	SE	LL	UL	p
(Intercept)	7.32	1.55	4.25	10.39	0.00
Race Load	0.00	0.00	0.00	0.00	0.00
REST-Q Recovery	-0.04	0.10	-0.24	0.17	0.73
REST-Q Stress	-0.16	0.16	-0.48	0.16	0.33
Optimism	0.02	0.05	-0.08	0.12	0.64

Note: LL,UL are abbreviations of the lower level and upper level 95% confidence intervals respectively

4.4 Discussion

It was hypothesised that alexithymia would have a negative relationship with perceived post-exercise recovery from training during the two weeks prior to the cycling race. It was also hypothesised that optimism would have a positive relationship with perceived post-exercise recovery from training during the two weeks before the cycling race. Neither of these hypotheses was satisfied with there being no relationship found between alexithymia or optimism and perceived post-exercise recovery from training during the two week period before the race. It was also hypothesised both alexithymia and optimism would negatively predict perceived recovery after the cycling race, these hypotheses also did not hold. Neither alexithymia nor optimism predicted with perceived recovery following the cycling Race upon going to bed that night.

4.4.1 Perceived Recovery two Weeks Prior to the Race

It was expected that during the two-week build-up to the cycling race that alexithymics would perceive they were less recovered from training. Feeling less recovered was expected because of the ongoing stresses of life as well as preparing for the race that individuals high in Alexihtymia would be expected to experience (Terock et al., 2020) meaning these individuals would also perceive to not be recovering from exercise training. The results found no relationship between alexithymia and perceived recovery from training. The lack of relationship may be because some alexithymic athletes will have more structure than others in their training. For individuals with a high structure to their training and high trait alexithymia, it would be expected that structure will help to reduce anxiety around training for these individuals (Christou-Champi et al., 2015; Koole et al., 2015), in the future training structure would be a variable worth investigation. This is potentially supported by the lack of influence of Alexithymia on average anxiety in the two weeks prior to the race (Table 4.1). Another variable not controlled for but potentially influencing alexithymia's relationship with perceived recovery is tapering. In the two weeks before a race, some of the athletes may have tapered, which would be expected to increase individuals perceived recovery and some may not have, potentially decreasing perceived recovery causing a washout in effects.

It was expected that optimism would have a positive effect on perceptions of post-exercise recovery from training. Optimists' positive effect on perceptions was expected due to individuals generally positive view of the world that optimists possess (Carver & Scheier, 2014), positive expectations (Carver & Scheier, 2014; Ran et al., 2017) and less chronic pain (Basten-Günther et al., 2018). In this study, the PRS scale (Laurent et al., 2011) was used to ask about recovery retrospectively each day one hour after training and overall, at the end of the day. There is no expectation or goal attached to asking the question retrospectively about that moment in time. Future studies may see differing results if the PRS scale was constructed with an expectation i.e. do you expect to be recovered by your next training session or on average do you feel you had recovered ready for your next training session. The introduction of a goal/expectation into the question may lead to different results as this would be in line with previous literature around optimism and placebo where is there is an expectation a placebo will work optimism has a positive relationship with placebo (Kern et al., 2020). For this study, however, optimism had no relationship with the average rating of perceived recovery, potentially due to lack of expectation in the questioning.

4.4.2 Perceived Recovery after the Race

Perceived recovery after the cycling race were expected to have a negative relationship with both alexithymia and optimism however neither did. An individual high in alexithymia may be expected to have perceived better recovery due to using the race to regulate emotion (Roberts & Woodman, 2015, 2017) with it being expected that anxiety will be high prior to the race but then alexithymics would feel a greater reduction in anxiety after the race and as a result in line with Fenichel (1939) but instead of physical risk causing anxiety the race is causing cognitive anxiety (Roberts & Woodman, 2015). If the race had induced anxiety reduction it would then be expected to individuals high in alexithymia would perceive greater recovery (Tanguy et al., 2018). Alexithymics did not perceive greater recovery, there may be a conflict for alexithymics as the race may have allowed emotion regulation (Roberts & Woodman, 2015) potentially reducing stress however after the race they are likely to also have physical aches and pains which they are likely to associate with perceiving worse recovery. The likelihood of the aches and pains causing greater discomfort is likely to also be increased in individuals high in alexithymia due to its links to somatisation (De Gucht & Heiser, 2003). The potential conflict between emotion regulation and somatisation may be why no relationship is seen between alexithymia and perceived recovery upon going to bed after the race.

For individuals high in optimism, it was expected they would perceive worse recovery, however, this hypothesis hinges on optimists inputting more effort during the cycle race. This increase in effort would then lead to a reduction in perceived recovery (Clemente et al., 2019; Ouergui et al., 2020). This rationaleis supported as Optimism positively predicted race load and race RPE (Table 4.1). Optimism also positively predicted anxiety two days before the race suggesting the race was important to them (Wiggins & Brustad, 1996). This was not the case there is also no relationship between optimism and race RPE suggesting that optimists did not engage more effort during the race.The lack of relationship is unexpected it would have been possible to predict a positive relationship providing that optimists expected to. After a cycling race such as the one in this investigation, it is unlikely athletes will need to recover quickly and a quicker recovery is not necessarily beneficial. It is proposed that optimists could perceive there is not a need to recover quickly and therefore perceive not being recovered or not necessarily recovering quickly as part of the process of recovery that is needed. A lack of expectation and perceptual need to recover opens up the possibility that optimists may not collectively report high perceived recovery from the race, some may and some may not perceive they are recovered, which may be why there is no relationship between optimism and perceived recovery after the race. Additionally, as with the average rating prior to the race, there is no expectation in asking the PRS scale post-race which may be why optimism has no relationship with in the moment ratings of perceived recovery. There is a lack of expectation when the PRS scale is asked as it is asked at the moment about a specific point in time, whereas expectation could be placed upon the PRS scale if participants had been asked how recovered they thought they would be for example by their next training or their next race. Formulating the question like this places an expectation rather than being in the moment and in this scenario, optimists may rate higher than low optimists due to their positive future outlook whereas at the moment this is potentially lost. as already mentioned the lack of relationship was unexpected however is effort and expectation were having equal and opposite effects on optimists in opposite direction this may have caused a wash out of any effects.

4.4.3 Limitations

The perceived recovery measure used in this study was the PRS scale. The PRS scale is a single items question and therefore is aimed at encompassing overall recovery from exercise. The PRS scale was deliberately chosen because it allows investigation of overall perceived recovery which combines psychological,physiological and emotional response components of recovery (Laurent et al., 2011) which seemed most appropriate for this field-based study. For alexithymics and potentially optimists, however, a more in-depth recovery questionnaire that separates different areas of recovery such as physical and mental recovery may bring differing results. For alexithymic individuals, a scale that separates recovery into a minimum of mental and physical recovery may help to tease out post-exercise perceived recovery as it may help to differentiate the beneficial emotion regulation and the not beneficial to recovery physical aches and pains. The use of a more in-depth measure should be approached with caution however as the link between alexithymia and both somatisation and emotional difficulties may mean relationships will only be seen on the physical side of recovery. A multi-item measure that could be used to investigate recovery further is the Hecimoviche Peiffere Harbough Exercise Exhaustion Scale (HPHEES), (Hecimovich et al., 2014). The HPHEES scale contains items that refer to perceptions of both psychological and physiological recovery, if it held up as a two-factor model (psychological and physiological) under further analysis a two-factor approach would allow investigators to look more deeply into perception of physiological and perceptions of psychological recovery from exercise.

A limitation of this study was that the PRS scale, RPE scale and anxiety questions/questionnaires were only translated by a native Italian speaker. These questions were not back-translated. This means that the questionaries were not checked for any meaningful difference which back-translation allows for by translating back from Italian to English. As such it is impossible to know if there were any meaningful differences in the translation of these questionaries which is certainly a limitation for the PRS and RPE scales and the anxiety single-item question.

A final limitation of this study was that participant samples differed between prerace and post-race due to the completion rate of the questionnaires; therefore, any association between pre and post-race analysis should be approached with caution as the samples have some but do not completely cross over.

4.4.4 Future Directions

The lack of relationships between alexithymia and perceived recovery from training before a race and after the race shows the potential need to examine further variables within these relationships. Future research may wish to examine factors that potentially affect the environment or goals in the lead up to a race. It seems certainly for alexithymia that the presence of a training structure and set periods to recover may be of benefit to help with emotion regulation, these are two variables not investigated during this field study which could add strength to the findings. Again, the lack of relationships between optimism and perceived recovery from training before a race and after the race shows the potential need to examine further variables within these relationships. For optimism, it may be interesting to investigate their motivation and thoughts around exercise recovery to try and have a deeper understanding of how it aligns with their goals and plans to further understand and interpret the null findings of this study.

4.4.5 Conclusion

In conclusion, this study set out to investigate alexithymia and optimism's effect on perceptions of post-exercise recovery in the build-up to and after the cycling race, however, no relationships were found before or after the race for either personality trait. The surprising result of no relationships between either trait and recovery may mean further research into this area should investigate perceptions of post-exercise recovery using a multi-item measure.

5 General Discussion

5.1 Summary Chapter Aims

The overall aim of this thesis was to investigate the role of alexithymia and optimism on a post-exercise recovery across different settings. The thesis aim was addressed through the development of three experimental studies to investigate alexithymia and optimism independently to determine any relationship between either trait and post-exercise recovery in a laboratory setting (Chapter 2), and three-month training setting (Chapter 3) and an applied race setting (Chapter 4).

The primary aim of Chapter 2 was to investigate the effect of alexithymia and optimism on acute post-exercise recovery (measured by perceptual and hormonal markers for recovery) between two treadmill running bouts within a laboratory setting. A secondary aim was to investigate this effect in the acute period that followed the second treadmill bout. The primary aim of Chapter 3 was to investigate the effect of alexithymia and optimism on chronic exercise recovery over a three-month training period, as assessed by hair cortisol concentrations and perceptual recovery within a sporting student population. The secondary aim was to investigate the effect of alexithymia and optimism on perceptions of well-being and stress across this three-month training period. The primary aim of Chapter 4 was to examine the influence of alexithymia and optimism on post-exercise recovery, specifically ratings of perceived recovery during a two-week build-up to, and in the hours immediately, after an amateur cycling race.

5.2 Perceived recovery

Perceived recovery were measured across all three experimental chapters. The relationship between personality and perceived recovery varied depending on the trait (alexithymia or optimism) and the time of the measurement. alexithymia had a positive relationship with perceived recovery in between exercise bouts in Chapter 2 demonstrating that the more alexithymic an individual is, the more recovered they perceived themselves to be. No relationship was found between alexithymia and perceived recovery after the second exercise bout in the laboratory study (Chapter 2). However, in Chapter 3 there was a negative relationship between alexithymia and perceived recovery with more alexithymic individuals rating worse perceived recovery on average over the three-month period of weekly ratings. In Chapter 4, neither trait influenced perceived recovery during the two-week training build-up to the cycle race or upon going to bed the evening after competing in the race, alexithymia did not predict perceived recovery. This finding potentially points to context and time as influencing factors for alexithymic individuals when recovering from exercise, as the results for alexithymia varied across each of out chapter settings which vary in structure and time. Optimism, unlike alexithymia, showed no relationship with perceived recovery across any of the studies. The lack of influence of optimism on perceived recovery may be down to the lack of expectation when the perceived recovery status (PRS) scale was answered by participants. Individuals were not asked if they expected to recover but rather how recovered they felt. As a result, optimistic expectations may not have positively affected individuals perceptions leading them to rate without positive expectation and potentially more realistically about how they felt in the moment.

5.3 Hormonal Recovery

Hormonal recovery was investigated in the laboratory study (Chapter 2) and the longitudinal study (Chapter 3) but not in the cycle race study (Chapter 4). The laboratory study (Chapter 2) had the most in-depth examination of hormonal recovery markers measuring both cortisol and DHEA whereas the longitudinal chronic study (Chapter 3) only investigated cortisol. The results of Chapter 2 centered around the cortisol:DHEA ratio with alexithymia having a negative relationship with the ratio between the two treadmill running bouts, demonstrating a more hormonally balanced profile during the 75 min recovery period between the two exercise bouts (Leff-Gelman et al., 2020). Between exercise bouts neither DHEA nor cortisol when analysed independently showed a relationship with alexithymia. After the second treadmill running bout the ratio showed no relationship with alexithymia, likewise neither did DHEA independently, however cortisol when analysed independently showed a positive relationship with alexithymia.

The findings between alexithymia and the hormonal markers in Chapter 2 led to speculation that alexithymic individuals may be able to regulate cortisol and DHEA well between two exercise bouts however good regulation between exercise bouts may have come at the cost of high cortisol concentrations once the second exercise bout was complete. Speculation over alexithymic regulation led to the thought that alexithymia may have a positive relationship with hair cortisol chronically if alexithymia's positive relationship with acute cortisol synthesis happened repeatedly. Accordingly, it would be expected that a higher concentration of cortisol may be chronically evident when exercise training in this population. Assessing the chronic relationship over time by measuring a three-month sample of hair cortisol concentration, however, did not show a relationship between alexithymia and hair cortisol concentration. Contrary to previous literature (Hua et al., 2014) alexithymic individuals appear to have a relatively stable Hypothalamic Pituitary Adrenal (HPA) axis balance when studying an exercising population. Optimistic individuals were expected to have a balanced HPA axis however the lack of relationship that was seen between optimism and cortisol:DHEA markers across any of the experimental chapters implies optimism is not significantly affecting the HPA axis.

5.4 Alexithymia Results Summary

In an acute setting when combining the findings that alexithymia's balanced HPA axis activity in the exercising populations investigated with the superior subsequent performance and greater perceived recovery as seen in Chapter 2, alexithymia appears to be a helpful trait when needing to perform exercise bouts in relatively quick succession (i.e.,one hour). Chapter 3 helped us to investigate if alexithymics better acute performance, needs to be approached with for caution, because the acute benefits may also have negative long-term effects. The longitudinal results (Chapter 3) showed divergent outcomes between the hair cortisol and ratings of perceived recovery. For example, alexithymia had a negative relationship with perceived recovery whereby the more alexithymic an individual the less recovered they perceived themselves, on average, to be from training. However, alexithymia had no relationship with hair cortisol. These findings provide preliminary evidence that despite alexithymic individuals perceiving that they not recovered, hormonally there is no evidence within cortisol at least that physically these individuals are not recovering. The lack of relationship between alexithymia and hair cortisol is potentially surprising given the raised cortisol concentrations the more alexithymic an individual after the second exercise bout was completed in Chapter 2. The lack of relationship however seen with the ratio in Chapter 2 after the second exercise bout does potentially mean that the elevated cortisol concentrations were not concerning which is supported by the lack of relationship with hair cortisol in Chapter 3.

5.5 Alexithymia Discussion

As raised previously, across the experimental chapters there were some commonalities in results across the studies and there were also places where the results diverged. Alexithymias' relationship with perceptual recovery changed depending on the experimental setting. Perceptually in Chapter 2, there was both a positive relationship (felt more recovered) in between exercise bouts but no-relationship after a second exercise bout between alexithymia and perceived recovery whereas in Chapter 3 alexithymia had a negative relationship with perceived recovery (felt less recovered). Hormonally, experimental settings in some cases did and in some did not change the relationship between alexithymia and hormonal recovery from exercise. In Chapter 2 alexithymia's relationship with both the cortisol:DHEA ratio and cortisol alone changed depending on the section of the study the participant, between exercise bout alexithymia influences the ratio only, after the second bout it influenced only cortisol. A potential reason for the positive relationship, seen in Chapter 2, between alexithymia and perceived recovery only between exercise bouts was because of the certainty and structure which is known to help reduce anxiety (Aberg et al., 2021; Bohlin & Hunt, 1995; Huber et al., 1975; Papaioannou & Kouli, 2008). In the laboratory experiment (Chapter 2) participants were briefed before the experiment about exactly what was going to happen and what they needed to do creating structure and certainty. This certainty is lost after the second exercise bout as there is not another exercise bout to prepare for and the period of recovery is open-ended reducing certainty and potentially creating anxiety especially for alexithymic individuals (Ozsivadjian et al., 2020). In Chapters 3 and 4 there is not necessarily a set time to recover and therefore perceived recovery may be influenced more by (e.g. environment, time, training schedule, work) so by their applied/field nature there is of course less certainty during recovery in Chapters 3 and 4 in comparison to the recovery period between exercise bouts in Chapter 2. It is well documented that alexithymic individuals are more comfortable around certainty than uncertainty (Ozsivadjian et al., 2020) therefore when given a certain period of time to recover it is probably unsurprising that individuals higher in alexithymia rated higher perceived recovery as there was a set and designated time to recover. This certainty about when to recover is lost when asked after the second exercise bout in the laboratory study (Chapter 2) as there is no longer a specific exercise bout to recover/prepare for. It is also possible there is a lack of certainty in Chapters 3 and 4 depending on how to set and organise an individual's training is. As the participants tested are amateurs there training may have to fit around their work and as such may have to be flexible and move when work/family causes changes to plans for example. As such the level of prescription and rigidness of an individual's exercise programme may greatly influence the perceived recovery by alexithymic individuals as it may help to create certainty which may reduce anxiety (Ozsivadjian et al., 2020) which in turn may influence their perception due to structure. For example they may be led by the need to recover for the next training session for example.

Surprisingly alexithymia had a negative relationship with the cortisol:DHEA ratio between the two exercise bouts, however along with the perception of post-exercise recovery the relationship may have been helped in part due to the certainty of being set a period of time to recover and prepare for a subsequent exercise bout. A set recovery time between exercise bouts would be expected to reduce anxiety for alexithymic individuals (Vermeulen & Luminet, 2009) and appeared to match with their perception of better recovery. This hormonal relationship was not seen in the chronic hair cortisol concentrations measured in Chapter 3 where there was no relationship despite high cortisol concentrations after the second exercise bout in the laboratory (Chapter 2). Exercise may be having a positive influence on alexithymic individuals HPA axis regulation which protects them from the heightened cortisol concentrations seen in previous literature in non-exercising populations (Härtwig et al., 2013; Hua et al., 2014; Timary et al., 2008). Exercise has been demonstrated to have positive health benefits for stress regulation and the HPA axis (Duclos & Tabarin, 2016; Zschucke et al., 2015), so if the health benefits and stress regulation effects are stronger than alexithymia's influence the positive effect of exercise on health and stress and negative effects of alexithymia may cancel each other out which may explain the lack of relationship between alexithymia and chronic cortisol.

The results across all three chapters have potential implications for alexithymic individuals when undertaking exercise training and competition. From a training perspective, alexithymic individuals are likely to be at risk from overtraining and burnout especially if they become dependent on exercise (Van Landeghem et al., 2019). Exercise dependence increases the risk of both physiological and psychological harm through a maladaptive pattern of exercise (Hausenblas & Downs, 2002; Van Landeghem et al., 2019). Exercise dependency has been sparsely investigated within alexithymia however because individuals high in alexithymia have strong links with self-harm (Norman et al., 2020; Norman & Borrill, 2015) there is strong theoretical rationale with some evidence for this occurring (Manfredi & Gambarini, 2015; Van Landeghem et al., 2019). If alexithymic individuals are drawn to exercise and are at risk from exercise dependency then monitoring and ensuring exercise recovery is very important. When in a training environment (Chapter 3) it was found that alexithymic individuals perceived a worse weekly average recovery however, there was no relationship found when investigating chronic cortisol over the same time period. The lack of relationship between alexithymia and chronic cortisol potentially means that although individuals higher in alexithymia chronically perceived they were less recovered from training when looking specifically at the HPA axis, the negative relationship seen with the perceived recovery was not mirrored across the same time frame with hair cortisol (Chapter 3). Moreover, acutely (Chapter 2) they appear to even display a potentially more favourable response (lower cortisol:DHEA ratio) although this was only seen between exercise bouts. These findings for alexithymia could very cautiously be interpreted to suggest that alexithymics post-exercise recovery is causing psychological difficulties/stresses however physiologically they are recovering, although they may not perceive they are.

Previously only theoretical rationale had been developed about alexithymic individuals producing a better athletic performance (Roberts & Woodman, 2015, 2017). Although the laboratory study (Chapter 2) did not investigate a singular performance it has demonstrated a negative relationship between alexithymic individuals and the ability to perform again within close proximity to the original exercise bout. Explicitly more alexithymic individuals performed better on the second exercise bout and therefore had a subsequent performance. These results provide some evidence to support the thoughts of Roberts & Woodman (2015) that alexithymia will be beneficial for sporting performance. There has been to our knowledge no investigation of alexithymia and post-exercise recovery therefore all three experimental studies add to the understanding of alexithymia's influence on both perceptual and hormonal recovery from exercise across acute, longitudinal and race settings (Chapters 2, 3 & 4).

5.6 Optimism Results Summary

Optimism showed no relationships with perceived post-exercise recovery or hormonal post-exercise recovery in any setting across Chapters 2, 3, and 4. The lack of relationship is particularly surprising given the existing positive relationships between optimism and health (Scheier & Carver, 2018), goal attainment (Geers, Wellman, Seligman, et al., 2010) and healthy behaviours (Steptoe et al., 2006). These results may however tentatively reveal that when asked about post-exercise recovery at the moment, rather than expected recovery in the future, optimistic individuals are aligned perceptually with the body's physical and psychological recovery rather than putting the positive perceptual skew expected of optimists.

5.7 Optimism Discussion

The lack of relationship in any setting between optimism and perceived recovery, or hormonal recovery was unexpected. It is possible however that within our amateur population the drive and motivation to exercise by optimistic individuals could be very different. Some optimistic individuals may be competitive, and goal-driven (Croom & Bono, 2017; Geers et al., 2009; Medlin & Faulk, 2011) however for others their exercise participation may be a health-protecting behaviour (Baker, 2007; Gassman, 2019; Steptoe et al., 2006) and therefore the competitive aspect of exercise is potentially not of importance. It would be expected that optimists engaging in exercise for competition (a goal) would expect to need greater recovery and feel less recovered than those engaging for health outcomes. This engagement by optimists would be particularly true in the context of a chronic training setting (Chapters 2 & 3). Optimists greater need to recover would be expected due to the effort engaged in exercise by optimists when there is a priority goal (Geers et al., 2009; Segerstrom & Solberg Nes, 2006). It is known that optimists engagement and effort change are dependent on goal priority, the higher priority of the goal the greater their engagement and effort (Geers et al., 2009; Geers, Wellman, Fowler, et al., 2010). This was also seen in Chapter 3 as optimism had a positive relationship with training hours, optimists trained more. Contrary to alexithymia, optimism has a negative relationship with burnout amongst competitive athletes (Berengüí et al., 2013; Chen et al., 2008; Gustafsson & Skoog, 2011). It could therefore be expected that again, particularly in a chronic training setting, optimists use their resources and engagement well to avoid burning out and recover well. Chapter 3 showed some tenuous support for this also with optimists perceiving they are less stressed and have higher level of perceived well-being. Optimists effective use of resources and engagement would therefore mean that amongst competitive optimistic athletes these individuals may need more recovery due to engaging more effort into achieving their competitive sporting goals. Optimists however also appear to theoretically have good resources (Segerstrom & Solberg Nes, 2006) to ensure they recover well and do not burnout. Optimists engaging in exercise for positive health outcomes would potentially not engage as much effort when performing as their goal is to stay healthy rather than to compete. These individuals may not need to recover as much as theoretically they may be engaging less effort as the goal is health rather than competition.

When coupling the difference in motivation amongst high optimists and their potentially realistic perceived recovery when asked at the moment there is, therefore, potentially different needs and feeling of recovery. The potential realistic perceived recovery scores given by optimists due to the in the moment rather than expectation nature of the PRS scale then it is easier to see how there may be no relationship between optimism and recovery directly. There is however the potential for optimism to act as a moderator between training load and perceived recovery, for example, or equally optimism and recovery's relationship may be moderated by effort. Throughout the thesis, no relationships were found between optimism and post-exercise recovery however this research, therefore, suggests that optimism may need to be explored in the post-exercise recovery domain through more indirect effects using mediation for example. For example, mediation analysis could be used to explore the indirect effect of goal-priority on optimism and the relationship with post-exercise recovery. Alternatively, an interaction approach through moderation could be used for example to explore if perceived exertion moderates optimism and post-exercise recovery's relationship. The potential differing motivations for engaging may be harnessed to better explain the lack of relationship between optimism and post-exercise recovery or used to explain potential indirect or moderating effects.

5.8 Relationship between Alexithymia and Optimism

Throughout this thesis, the relationships between Alexithymia and Optimism post-exercise recovery have been explored with each trait in isolation. Theoretically, it is unlikely for an individual to be high in Alexithymia and high in Optimism due to the differences between each trait. Alexithymia and Optimism as already explained are related generally to opposite outcomes, for example, Alexithymia is related to poorer general health whereas Optimism is positively related to better general health, Optimists generally have a good understanding of their emotions (Augusto-Landa et al., 2011), however Alexithymic individuals by definition struggle with identifying and describing emotions. Simple correlations between Alexithymia and Optimism scores across the three studies in this thesis show no correlation for the lab (r=.05, p=.73) and cycle race studies (r=-.08, p=.30) There was a significant negative correlation between Alexithymia and Optimism in the longitudinal study (r=-.43, p=.00). The relationship between the two traits and then their further relationship with post-exercise recovery was not investigated in this thesis. The main reason for not investigating this was simplicity. This is the first body of work to investigate personality's influence on post-exercise recovery therefore it was felt the simplest presentation would be to investigate the traits separately on post-exercise recovery.

5.9 Other Personality Traits

This thesis has only explored the traits of alexithymia and optimism independently on post-exercise recovery. An individual's personality can be made up of many different traits and these could of course affect post-exercise recovery in conjunction with alexithymia and optimism or independently. Several traits which may play an important role in post-exercise recovery are narcissism, rumination and perfectionism. In all of these traits, investigation in the general population would be warranted.

Narcissism is derived from the Greek myth of Narcissus, a proud hunter who fell in love with his reflection. The trait therefore reflects the love of the image of the self. In a sporting context, providing there is an opportunity for glory individuals high in trait narcissism outperform those lower in trait narcissism by working harder (Roberts et al., 2019). This increase in effort which narcissists invest in sporting performance where there is an opportunity for glory may affect post-exercise recovery.

One would expect that narcissists may need more recovery time after competitions where the opportunity for glory is high for example due to increasing their effort so as to perform thier best. On the side, narcissists may not invest great amounts of effort into training, particularly if they feel the opportunity for glory in training is low, therefore needing less recovery than individuals low in narcissism. Narcissists are also known to have chronically high cortisol (Edelstein et al., 2010; Pfattheicher, 2016; Reinhard et al., 2012), which may impact physiological recovery from exercise. Narcissism has also been shown to predict a greater number of daily hassles and life stress (Frederick & Morf, 1995). In summary, it would be expected in general life narcissists are more stressed physiologically and psychologically which may affect their post-exercise recovery; however, the extent to which post-exercise recovery is affected may be dictated by the opportunity for glory in the situation and the resulting effort put forth.

Narcissism and alexithymia are not often investigated together. A phenotypic study showed a negative correlation between alexithymia and narcissism, (Cairncross et al., 2013). There is some evidence narcissism is positively associated with Optimism (Hickman et al., 1996), as narcissists' grandiosity and perceived superiority are likely to lead to more optimistic beliefs.

Trait rumination is a disposition to replay and rethink situations again and again (Smith & Alloy, 2009). Rumination has received scant attention in a sporting context, however the physiological reactivation seen whilst ruminating may well influence post-exercise recovery. When an individual ruminates (rethinks about a previous situation) the body reactivates physiologically, in that hormones and heart rate increase as if the situation is happening in real time although not to the same levels as during the original experience. Therefore, as well as experiencing potential psychological distress via ruminating, the body also relives the physiological stress of the situation (Zoccola et al., 2010; Zoccola & Dickerson, 2015). This process has implications for post-exercise recovery as individuals who are prone to ruminating may rethink and rehash a sporting performance or training again, and again. This ruminating may then in turn cause psychological and physiological reactivation which may hinder an individual's recovery from the exercise. It would be expected that ruminators would not recover well as their body continues to go through physiological and psychological stress after the sport/exercise. Rumination and alexithymia are both associated with depression (Bailer et al., 2017), however the relationship between the two traits has rarely been investigated.Schiema et al. (2011), show mixed correlations between the different facets of each trait rather than of each trait overall, in that the different facets of Alexithymia negatively and positively correlate with rumination. Within current research, Optimism is often used as a moderator between rumination and psychological variables such as anxiety, suicidal ideation, and catastrophising where it acts to reduce the effect rumination can have on the outcome (Hood et al., 2012; Tucker et al., 2013; Yu et al., 2015).

Perfectionism reflects a disposition to regard anything short of perfection as unacceptable along with unrealistic evaluation (Shafran et al., 2002). Perfectionism is often split into perfectionistic strivings (PS) and perfectionistic concerns (PC) with each dimension showing different and often opposing relationships with psychological and physiological variables (Stoeber & Gaudreau, 2017). PS are often conceptualised as striving for perfection whereas PC reflect a desire to avoid imperfection (Stoeber & Gaudreau, 2017). PS and PC have been shown to have an opposing relationship with cortisol response to a stressor with PS being associated with a lower cortisol response and PC with a high cortisol response, (Richardson et al., 2014). Further, opposing relationships have also between established between PS and PC and other outcomes including coping and affect (with PS associated with adaptive coping and positive affect and PC with maladaptive coping and negative affect, (Stoeber & Childs, 2010). Given the opposing influence of perfectionistic strivings and concerns, it may be expected that the two dimensions will have different effects on post-exercise recovery. It would be expected that PS would be associated with better recovery as a result of lower cortisol responses to stress and better coping resources, in contrast, the opposite might be expected for PC.

Perfectionism and alexithymia are both associated with eating disorders and suicide risk (De Berardis et al., 2017; Marsero et al., 2013). The relationships between the two traits are rarely examined, however Lundh et al., (2002) showed perfectionism predicted TAS-20 scores such that increases in perfectionistic concerns were associated with increased TAS-20 scores. Similarly, relationships between perfectionism and optimism are rarely investigated. In one study that did explore relations between these variables, Black and Reynolds (2013) found a mediating effect of Optimism in the relationship between perfectionism and depression.

Whilst these personality traits could be investigated, the focus of this thesis was on Alexithymia and optimism. Therefore, alexithymia and optimism will be the focus of the further paragraphs of this general discussion. These other traits will not be mentioned any further in the discussion.

5.10 Contribution of this thesis to the existing literature

Post-exercise recovery is a popular topic for scientific research and observations in mechanisms behind exercise recovery e.g. heart rate recovery, hormonal balance and strategies implemented to improve recovery e.g. massage, cryotherapy, foam-rolling are plentiful. The consideration that individual difference may have an effect on these mechanism and strategies have received comparatively less attention (Kellmann et al., 2018). This research is believed to be the first to examine the influence of one particular type of individual difference, personality, on post-exercise recovery and more specifically the separate influences of alexithymia and dispositional optimism on post-exercise recovery. This novel body of research has demonstrated across a range of settings that alexithymia can influence post-exercise recovery in some way both acutely and chronically. Optimism on the other hand showed no influence on post-exercise recovery despite a strong theoretical rationale for relationships to exist.

A further novel contribution of this body of research is the use of the cortisol:DHEA ratio when investigating post-exercise recovery. Previous literature has tended to focus on the use of cortisol as a singular marker (Cevada et al., 2014; VanBruggen et al., 2011), however, the laboratory study (Chapter 2) showed that within an acute setting the ratio allows us to demonstrate HPA axis balance where there were no relationships with singular markers (cortisol:DHEA). If researchers can continue to investigate the ratio of cortisol:DHEA particularly in the post-exercise recovery setting it may allow a clearer picture of the function of the HPA axis after exercise, as it enables investigations into the balance of the HPA axis. Investigating the ratio would be of particular interest in hair concentrations DHEA can be investigated in general population in hair (Kintz et al., 1999; Qiao et al., 2017). Investigating DHEA concentrations in hair alongside cortisol concentrations would allow the investigation of the chronic balance of the HPA axis.

5.11 Limitations

Throughout the experimental chapters, all results can only be interpreted amongst amateur athletes. The life of a professional is ultimately different to those of an amateur due, in some cases, to not having to balance job demands alongside sporting activities. In addition, these results should not be interpreted amongst elite athletes as our populations, in general, were not of elite-level e.g. Olympic/commonwealth/world cup/European level. The stresses, strains, schedules, and outside help (coaches/physios etc.) of elite and professional athletes is likely to mean their experiences of post-exercise recovery may be very different (Tavares et al., 2017) as they may have less responsibility and their recovery may be more planned and prescribed as well as having better access to recovery tools e.g sports massage, cryotherapy chambers. The two traits explored in this thesis alexithymia and optimism in the future would warrant further investigation but potentially with further variables explored to help explain each trait's unique relationship with post-exercise recovery. The use of further variables applicable to each trait such as anxiety, perceived effort, goal-priority would then allow investigations into indirect effects through mediation and investigation into how variables such as personality and relevant further variables are interacting in post-exercise recovery through moderation.

Both Alexithymia and Optimism have been treated throughout this thesis as stable traits which are continuous variables. As such the relationship between each trait and post-exercise recovery was investigated through linear relationships. This approach was taken due to wanting to investigate each personality trait from a linear perspective to not separate individuals into high, low and those in between. It was felt that if this thesis had used cut-offs in the investigation this would not represent the continuous nature the traits have. This use of an expected linear relationship is limited as it may be that different relationships between the variables investigated in the thesis may be found at extreme ends on either trait. As such in future investigations between personality and post-exercise recovery may wish to investigate a curvilinear relationship and/or the use of high and low scores to investigate the relationship between personality and post-exercise recovery. The use of cut-offs would be easier for Alexithymia where there are already reasonably established cut-offs to determine whether individuals are high or low in Alexithymia. Most recently however in Bagby et al.,(2020) review, it was suggested that their use of cut-offs was a mistake as it naturally makes the alexithymia construct categorical rather than dimensional. Since its inception, there have been multiple taxometric studies (Mattila et al., 2010; Parker et al., 2008) showing strong support for Alexithymia as a dimensional construct and therefore the use of cut-offs should be avoided.

Throughout this thesis, Alexithymia and Optimism have both been measured through self-report questionnaires. The use of self-report questionnaires does have its limitations as it requires a certain level of self-awareness and introspection. The two traits examined in the thesis both have the potential to influence the self-reporting of the traits themselves and other variables measured throughout the thesis. For Alexithymia the use of a self-report questionnaire is potentially problematic, Alexithymia by its very nature reflects a difficulty in identifying and describing emotions and externally orientated thinking, thus individuals high in this trait may struggle with self-report. The question of the use of self-report by Alexithymic individuals is due to their difficulty in self-reflection (Taylor et al., 1997). This potential lack of self-reflection by Alexithymic individuals certainly does pose a limitation for the use of self-report throughout this thesis. For Dispositional optimism self-report also causes potential problems due to the tendency for those high in Optimism to potentially have an inflated positive view. Throughout this thesis there is no use of observational or informant reports, therefore the findings within this thesis are limited by the sole use of self-report measures of both personality and other psychological variables. Having said this, it is notable that both traits have very well-established research bases, with scores on these measures predicting several of physiological and behavioural outcomes in ways that are consistent with theorising (For example,(Bagby et al., 2020; Carver & Scheier, 2014)). Thus, despite the noted challenges there is merit in assessing these scales via self-report.

This thesis only investigated the personality traits of alexithymia and optimism independently on post-exercise recovery. There is a wealth of personality traits which may affect post-exercise recovery both independently and in relation to both alexithymia and optimism (see pg.122). In this thesis I took a single trait approach which by its very nature only demonstrates the effect of a single personality trait on post-exercise recovery rather than an individual's personality which will be made up of many traits. It was felt there was a need for this thesis to concentrate on single traits which had a strong theoretical rationale for investigation however in the future further traits could be looked at in isolation or in combination.

5.12 Future Directions

In the future when exploring the influence of alexithymia on post-exercise recovery studies it would be recommended to separately or in combination: take note of structure/certainty in the design of the study, to ensure anxiety is investigated, pain is investigated, and somatisation investigated. As previously speculated the potential influence of certainty within an experiment due to its structure/context in its design may influence alexithymic individuals post-exercise recovery therefore it should be considered in future research. Roberts (Roberts & Woodman, 2015, 2017) mention the theoretical use of sporting performance by alexithymic individuals to regulate anxiety. Further research would benefit from investigating anxiety before and after a performance and the potential influence anxiety may have on both acute (e.g., within the first hour) and longer-term post-exercise recovery. Alexithymia has strong links with somatisation (De Gucht & Heiser, 2003), exercise may enable alexithymic individuals to both somatise and understand emotions. It is well-conceived that exercise will lead to individuals feeling tired and potentially having aches and pains (Borg et al., 1985). It therefore may be likely that alexithymic individuals will find it easier to rate how physically recovered they are or are not feeling rather than how psychologically recovered due to their difficulties with emotion (Bagby et al., 1994). Alexithymic individuals' recovery may also be further complicated by the somatisation of psychological symptoms of exercise recovery being displayed as physical symptoms (Mattila et al., 2008; Rief et al., 2001). The potential different effects of perception of psychological and physiological recovery could attempt to be explored with a more in-depth measure of recovery rather than a single item global rating of perceived post-exercise recovery.

As already discussed for this thesis there was an expectation that the relationship between personality and post-exercise recovery would be linear ,however, this may not be the case. In the future, nonlinear relationships between different traits and recovery-based outcomes could be explored. Assessment through a nonlinear relationship would allow more flexibility to analyse the traits and the possibility for extreme ends of the spectrums to have different effects on recovery.A second way to further explore the relationship between personality traits and post-exercise recovery would be to remove the "middle" section of personality scores to only investigate the high and low ends of each trait. Using high and low scores may help to show different, or stronger relationships between personality and post-exercise recovery as it is investigating the more distinct ends of the continuum. This approach should be taken with caution for Alexithymia, as discussed previously in the limitations section.

As previously discussed, there are many different traits which may independently or collectively influence post-exercise recovery. In the future, these traits such as narcissism, perfectionism, and rumination could be looked at independently with post-exercise recovery. . An alternative future direction would be to use a technique such as pattern recognition to simultaneously investigate personality traits and highlight the personality traits which are important to post-exercise recovery. This approach poses its challenges due to the dichotomous outcome needed (e.g., recovered or not recovered and how this would be defined) but is an avenue that could be explored.

Finally, a further factor not explored in this thesis is alexithymia and self-harm's relationship. Previous research has demonstrated how alexithymia has links to self-harm with the believed mechanism being that the self-harm allows the individual to feel their emotions through physically hurting themselves (Norman et al., 2020; Norman & Borrill, 2015). In an exercise setting alexithymic individuals may enjoy the feeling of not being recovered and having sore muscle etc as it allows them to 'feel' something. Further exploration of feeling through exercise pain/aches would enable individuals to better understand alexithymics recovery and potentially may mean these individuals do not engage with strategies to improve recovery.

In the future when exploring optimism's relationship with post-exercise recovery researchers should think about expectation, monitor motivation and importance of recovery and use of/approach to recovery strategies. It would be of interest to see if optimism's relationship with post-exercise recovery exists if asked if they are expected to recover as opposed to how recovered they feel at that moment in line with previous findings that expectation that a placebo will work causes a positive relationship between optimism and placebo (Geers, Wellman, Fowler, et al., 2010; Kern et al., 2020). A second area worth exploring is the speculated divide in motivation to exercise between competing/goal-driven motivation and health motivations. This motivation may then also have a knock-on effect on how important post-exercise recovery is and also how much optimists feel it is needed. For example, optimists who are increasing effort to compete and try as hard as they can in competition need more recovery than those completing exercise for health and well-being.

Finally, an investigation into optimists approaches to recovery in particular the use of recovery strategies would be of interest. This thesis did not capture the use of post-exercise recovery strategies however optimists are known to engage with and adhere well to post-operative procedures (Scheier et al., 1999), and health programmes (Geers, Wellman, Seligman, et al., 2010), therefore optimists may engage well and see benefit from post-exercise recovery strategies, particularly if optimistic individuals expect the recovery strategies to be beneficial to recovery (Geers, Wellman, Fowler, et al., 2010; Kern et al., 2020).

5.13 Conclusion

The overall aim of this thesis was to investigate the role of personality on a post-exercise recovery across different settings which was conducted through three experimental chapters. The findings from the different studies demonstrate the potential for alexithymia's relationship with post-exercise recovery to change depending on whether it is an acute or longitudinal setting (Chapters 2 & 3). In the acute setting of Chapter 2, alexithymia predicted greater perceived recovery so the more alexithymic an individual the more recovered they felt. The opposite was seen however in the longitudinal setting of Chapter 3 where alexithymia predicted a poorer perceived recovery where more alexithymic individuals felt less recovered. No relationship was seen between alexithymia and post-exercise recovery from training before a race and no relationship was seen with post-race recovery after an amateur cycle race either. These mixed results demonstrate that setting appears to be affecting alexithymic individuals' perceived recovery. A similar mixed result is seen when analysing alexithymia and HPA axis hormonal markers of recovery across the studies. In an acute setting (Chapter 2) alexithymia appeared to influence these markers both positively for recovery (between exercise bouts) and negatively (after the 2nd exercise bout) and no relationship was seen chronically between alexithymia and hair cortisol concentrations. The change in alexithymia's relationship with hormonal markers of recovery again shows the potential influence of setting on alexithymia's relationship with post-exercise recovery. Optimism showed no relationship with post-exercise recovery across any of the chapters. A potential explanation for the lack of relationships revolves around the lack of expectation attached when asking about recovery perceptually and is something that could be investigated further in the future. This thesis demonstrated that personality can sometimes influence post-exercise recovery in certain scenarios.

6 References

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8 Appendix

9 Chapter 2 Questionaires

9.1 Life Orientation Scale - Revised (LOT-R)

LIFE ORIENTATION TEST –Revised (LOT-R)

Please be as honest and accurate as you can throughout. Try not to let your response to one statement influence your responses to other statements. There are no "correct" or "incorrect" answers. Answer according to your own feelings, rather than how you think "most people" would answer.

A = I agree a lot

B = I agree a little

C = I neither agree nor disagree

D = I disagree a little

E = I disagree a lot

1. In uncertain times, I usually expect the best.
2. It's easy for me to relax.
3. If something can go wrong for me, it will.
4. I'm always optimistic about my future.
5. I enjoy my friends a lot.
6. It's important for me to keep busy.
7. I hardly ever expect things to go my way.
8. I don't get upset too easily.
9. I rarely count on good things happening to me.
10. Overall, I expect more good things to happen to me than bad.

Scoring:

Items 3, 7, and 9 are reverse scored (or scored separately as a pessimism measure). Items 2, 5, 6, and 8 are fillers and should not be scored. Scoring is kept continuous – there is no benchmark for being an optimist/pessimist.

9.2 Toronto Alexithymia Scale (TAS-20)

Sex: M / F **Age:** **Date:** **ID #:**

T A S – 20

Using the scale provided as a guide, indicate how much you agree or disagree with each of the following statements by circling the corresponding number. Give only one answer for each statement.

Circle 1 if you STRONGLY DISAGREE
Circle 2 if you MODERATELY DISAGREE
Circle 3 if you NEITHER DISAGREE NOR AGREE
Circle 4 if you MODERATELY AGREE
Circle 5 if you STRONGLY AGREE

	Strongly Disagree	Moderately Disagree	Neither Disagree Nor Agree	Moderately Agree	Strongly Agree
1. I am often confused about what emotion I am feeling.	1	2	3	4	5
2. It is difficult for me to find the right words for my feelings.	1	2	3	4	5
3. I have physical sensations that even doctors don't understand.	1	2	3	4	5
4. I am able to describe my feelings easily.	1	2	3	4	5
5. I prefer to analyze problems rather than just describe them.	1	2	3	4	5
6. When I am upset, I don't know if I am sad, frightened, or angry.	1	2	3	4	5
7. I am often puzzled by sensations in my body.	1	2	3	4	5
8. I prefer to just let things happen rather than to understand why they turned out that way.	1	2	3	4	5
9. I have feelings that I can't quite identify.	1	2	3	4	5
10. Being in touch with emotions is essential.	1	2	3	4	5

Date: **ID #:**

T A S – 20

	Strongly Disagree	Moderately Disagree	Neither Disagree Nor Agree	Moderately Agree	Strongly Agree
11. I find it hard to describe how I feel about people.	1	2	3	4	5
12. People tell me to describe my feelings more.	1	2	3	4	5
13. I don't know what's going on inside me.	1	2	3	4	5
14. I often don't know why I am angry.	1	2	3	4	5
15. I prefer talking to people about their daily activities rather than their feelings.	1	2	3	4	5
16. I prefer to watch "light" entertainment shows rather than psychological dramas	1	2	3	4	5
17. It is difficult for me to reveal my innermost feelings, even to close friends.	1	2	3	4	5
18. I can feel close to someone, even in moments of silence.	1	2	3	4	5
19. I find examination of my feelings useful in solving personal problems.	1	2	3	4	5
20. Looking for hidden meanings in movies or plays distracts from their enjoyment.	1	2	3	4	5

T A S – 20

Scoring Instructions

1. The scoring for items 4, 5, 10, 18, and 19 should be reversed (i.e., a rating of 1 becomes scored 5; 2 = 4; 3 = 3; 4 = 2; and 5 = 1).

2. Once the scoring for these items is reversed, total all 20 items.

3. There should be no more than two or three missing values in the total scale and no more than one missing value in any of the three factor scales. A missing value can be replaced by the mean score of the remaining items on the same factor scale. Be careful to score correctly for the negatively keyed items.

4. Although alexithymia is a dimensional construct, and TAS-20 scores best analyzed as a continuous variable, the following empirically derived cutoff scores may be used for identifying individuals with high or low alexithymia.

$\geq$ 61 = high alexithymia ("alexithymia")

$\leq$ 51 = low alexithymia ("nonalexithymia")

The Three Factor Structure of the TAS-20

Factor 1: Difficulty Identifying Feelings

1. I am often confused about what emotion I am feeling.
3. I have physical sensations that even doctors don't understand.
6. When I am upset, I don't know if I am sad, frightened, or angry.
7. I am often puzzled by sensations in my body.
9. I have feelings that I can't quite identify.
13. I don't know what's going on inside me.
14. I often don't know why I am angry.

Factor 2: Difficulty Describing Feelings

2. It is difficult for me to find the right words for my feelings.
4. I am able to describe my feelings easily.
11. I find it hard to describe how I feel about people.
12. People tell me to describe my feelings more.
17. It is difficult for me to reveal my innermost feelings, even to close friends.

Factor 3: Externally-Oriented Thinking

5. I prefer to analyze problems rather than just describe them.
8. I prefer to just let things happen rather than to understand why they turned out that way.
10. Being in touch with emotions is essential.
15. I prefer talking to people about their daily activities rather than their feelings.
16. I prefer to watch "light" entertainment shows rather than psychological dramas.
18. I can feel close to someone, even in moments of silence.
19. I find examination of my feelings useful in solving personal problems.
20. Looking for hidden meanings in movies or plays distracts from their enjoyment.

Normative Data on the TAS-20 from an English-Speaking Adult Community Population

N = 1933 (880 men, 1053 women)

Mean age = 35.47 (SD = 12.55)

Mean education = 14.75 years (SD = 2.42)

	Factor 1	Factor 2	Factor 3	TAS-20
Men (N = 868)				
Mean	14.51	13.16	19.62	47.30
SD	5.22	4.10	4.67	11.32
Women (N = 1065)				
Mean	14.27	11.96	17.93	44.15
SD	5.20	4.21	4.63	11.19
Total (N = 1933)				
Mean	14.38	12.50	18.70	45.57
SD	5.21	4.20	4.72	11.35

Parker, Taylor & Bagby, ***Journal of Psychosomatic Research*****, 55: 269-275, 2003**

9.3 Percieved Recovery Status Scale (PRS Scale)

Perceived Recovery Status Scale

10	Very well recovered/Highly energetic
9	
8	Well recovered/Somewhat energetic
7	
6	Moderately recovered
5	Adequately recovered
4	Somewhat recovered
3	
2	Not well recovered/Somewhat tired
1	
0	Very poorly recovered/ Extremely tired

Using the table above please write down a number that best describes your level of recovery from this mornings exercise

____

9.4 Brunels Mood Scale (BRUMS) Fatigue only

MOOD QUESTIONNAIRE **Number:__________**

Participant ID: ________________________ ***Date:*** ______________________

Visit: ________________________________ ***Time:*** ______________________

Below is a list of words that describe feelings. Read each one carefully and then circle the corresponding number that best describes HOW YOU FEEL RIGHT NOW. Please ensure that you answer every question.

Highlighted in yellow fatigue scale

0 = not at all 1 = a little 2 = moderately 3 = quite a bit 4 = extremely

1. Panicky……………………………………………………………	0	1	2	3	4
2. Lively……………………………………………………………	0	1	2	3	4
3. Confused………………………………………………………...	0	1	2	3	4
4. Worn Out…………………………………………………………	0	1	2	3	4
5. Depressed………………………………………………………...	0	1	2	3	4
6. Downhearted…………………………………………………….	0	1	2	3	4
7. Annoyed………………………………………………………….	0	1	2	3	4
8. Exhausted………………………………………………………..	0	1	2	3	4
9. Mixed-up………………………………………………………......	0	1	2	3	4
10. Sleepy……………………………………………………………	0	1	2	3	4
11. Bitter…………………………………………………………….	0	1	2	3	4
12. Unhappy…………………………………………………………	0	1	2	3	4
13. Anxious………………………………………………………..	0	1	2	3	4
14. Worried………………………………………………………..	0	1	2	3	4
15. Energetic………………………………………………………	0	1	2	3	4
16. Miserable………………………………………………………	0	1	2	3	4
17. Muddled………………………………………………………..	0	1	2	3	4
18. Nervous………………………………………………………..	0	1	2	3	4
19. Angry…………………………………………………………… .	0	1	2	3	4
20. Active…………………………………………………………..	0	1	2	3	4
21. Tired…………………………………………………………….	0	1	2	3	4
22. Bad tempered…………………………………………………..	0	1	2	3	4
23. Alert…………………………………………………………….	0	1	2	3	4
24. Uncertain……………………………………………………….	0	1	2	3	4

9.5 State Trait Anxiety Index (STAI) state section only

STAI-State

DIRECTIONS:

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you feel *right* now, that is, *at this moment*. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

	NOT AT ALL	SOMEWHAT	MODERATELY SO	VERY MUCH SO
1. I feel calm	1	2	3	4
2. I feel secure	1	2	3	4
3. I am tense	1	2	3	4
4. I feel strained	1	2	3	4
5. I feel at ease	1	2	3	4
6. I feel upset	1	2	3	4
7. I am presently worrying over possible misfortunes	1	2	3	4
8. I feel satisfied	1	2	3	4
9. I feel frightened	1	2	3	4
10. I feel comfortable	1	2	3	4
11. I feel self-confident	1	2	3	4
12. I feel nervous	1	2	3	4
13. I am jittery	1	2	3	4
14. I feel indecisive	1	2	3	4
15. I am relaxed	1	2	3	4
16. I feel content	1	2	3	4
17. I am worried	1	2	3	4
18. I feel confused	1	2	3	4
19. I feel steady	1	2	3	4
20. I feel pleasant	1	2	3	4

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STAIP-AD Test Form Y
www.mindgarden.com

9.6 Rating Pecieved Exertion (RPE,CR-10) Scale

BORG CR10 Scale

0	Nothing at all
0.5	Extremely Weak
1	Very Weak
2	Weak (light)
3	Moderate
4	Somewhat Strong
5	Strong (heavy)
6	
7	Very Strong
8	
9	
10	Extremely Strong

RPE (Rate of Perceived Exertion)

RPE	Borg RPE Scale	Description	Description #2
1	6	no exertion at all	I'm watching TV and eating bon bons
	7	extremely light	
	8		
2	9	very light	I'm comfortable and could maintain this pace all day long
	10		
3	11	light	I'm still comfortable, but am breathing a bit harder
4	12		I'm sweating a little, but feel good and can carry on a conversation effortlessly
5	13	somewhat hard	I'm just above comfortable, am sweating more and can still talk easily
6	14		I can still talk, but am slightly breathless
7	15	hard (heavy)	I can still talk, but I don't really want to. I'm sweating like a pig
8	16		I can grunt in response to your questions and can only keep this pace for a short time period
8.5	17	very hard	
9	18		I am probably going to die
9.5	19	extremely hard	
10	20	maximal exertion	I am dead

10 Chapter 3 Additonal Questionaires

10.1 Percieved Stress Scale (PSS-4)

Perceived Stress Scale 4 (PSS-4)

(Cohen et al. 1983)

Instructions: The questions in this scale ask you about your feelings and thoughts during THE LAST MONTH. In each case, please indicate your response by selecting the option representing HOW OFTEN you felt or thought a certain way.

Never; Almost never; Sometimes; Fairly often; Very often

1. In the last month, how often have you felt that you were unable to control the important things in your life?
2. In the last month, how often have you felt confident about your ability to handle your personal problems?
3. In the last month, how often have you felt that things were going your way?
4. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?

Scoring Instructions:
Total score is determined by adding together the scores of each of the four items. Questions 2 and 3 are reverse coded.

Questions 1 and 4: 0 = Never; 1 = Almost never; 2 = Sometimes; 3 = Fairly often; 4 = Very often
Questions 2 and 3: 4 = Never; 3 = Almost never; 2 = Sometimes; 1 = Fairly often; 0 = Very often

Citation:
Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. *Journal of Health and Social Behavior, 24,* 385-396.

10.2 Well-Being Index (WHO-5)

Psychiatric Research Unit
WHO Collaborating Centre in Mental Health

WHO (Five) Well-Being Index (1998 version)

Please indicate for each of the five statements which is closest to how you have been feeling over the last two weeks. Notice that higher numbers mean better well-being.

Example: If you have felt cheerful and in good spirits more than half of the time during the last two weeks, put a tick in the box with the number 3 in the upper right corner.

Over the last two weeks:	All the time	Most of the time	More than half of the time	Less than half of the time	Some of the time	At no time
1. I have felt cheerful and in good spirits	5	4	3	2	1	0
2. I have felt calm and relaxed	5	4	3	2	1	0
3. I have felt active and vigorous	5	4	3	2	1	0
4. I woke up feeling fresh and rested	5	4	3	2	1	0
5. My daily life has been filled with things that interest me	5	4	3	2	1	0

Scoring:

The raw score is calculated by totaling the figures of the five answers. The raw score ranges from 0 to 25, 0 represent- ing worst possible and 25 representing best possible quality of life.

To obtain a percentage score ranging from 0 to 100, the raw score is multiplied by 4. A percentage score of 0 represents worst possible, whereas a score of 100 represents best possible quality of life.

Interpretation:

It is recommended to administer the Major Depression (ICD-10) Inventory if the raw score is below 13 or if the patient has answered 0 to 1 to any of the five items. A score below 13 indicates poor wellbeing and is an indication for testing for depression under ICD-10.

Monitoring change:

In order to monitor possible changes in wellbeing, the percentage score is used. A 10% difference indicates a significant change (ref. John Ware, 1995).

10.3 Hair Demographic Questionaire

HCQ

Hair Cortisol Questionnaire

You are about to complete a short survey that asks about your hair routine.

Please try to answer the statements as carefully and as honestly as possible based upon your best knowledge. **There are no right or wrong answers. Your answers will only be seen by the research team and then will be made anonymous so nobody else can attribute them to you.**

What is your DOB? (DD-MM-YYYY)

____

What is your height? (cm)

____

What is your weight? (kg)

____

What is your ethnicity?

- ○ White
- ○ Hispanic or Latino
- ○ Black or African American
- ○ Native American or American Indian
- ○ Asian / Pacific Islander
- ○ __________ Other, please specify

Have you smoked in the last 3 months?

- ○ Yes

○ No

Are you a current smoker?

○ Yes
○ No

If yes, how many cigarettes do you smoke per day on average? Please also provide details of the brand.

[ ]

Using the table below select the number (0 to 7) that best describes your **general activity level** for the past month.

○ Do not participate regularly in programmed recreation sport or heavy physical activity

0. Avoid walking or exertion, for example, always use elevators, drive whenever possible instead of walking

○ Do not participate regularly in programmed recreation sport or heavy physical activity

1. Walk for pleasure, routinely use stairs, occasionally exercise sufficiently to cause heavy breathing or perspiration

○ Participate in recreation or work requiring modest physical activity, such as golf, horseback riding, gymnastics, table tennis, bowling, weighting lifting, yard work.

2. 10-60 min per week

○ Participate in recreation or work requiring modest physical activity, such as golf, horseback riding, gymnastics, table tennis, bowling, weighting lifting, yard work.

3. Over 60 min per week

○ Participate regularly in heavy physical exercise such as running or jogging, swimming, cycling, rowing, skipping rope, running in place or engaging in vigorous aerobic exercise such as tennis basketball or handball.

4. Run less than 1 mile (1.6 km) per week or spend less than 30 min per week in comparable physical activity

○ Participate regularly in heavy physical exercise such as running or jogging, swimming, cycling, rowing, skipping rope, running in place or engaging in vigorous aerobic exercise such as tennis basketball or handball.

5. Run 1 to 5 miles (1.6 to 8 km) per week or spend 30 to 60 min per week in comparable physical activity

- ○ Participate regularly in heavy physical exercise such as running or jogging, swimming, cycling, rowing, skipping rope, running in place or engaging in vigorous aerobic exercise such as tennis basketball or handball.

6. Run 5 to 10 miles (8 to 16 km) per week or spend 1 to 3 h per week in comparable physical activity

- ○ Participate regularly in heavy physical exercise such as running or jogging, swimming, cycling, rowing, skipping rope, running in place or engaging in vigorous aerobic exercise such as tennis basketball or handball.

7. Run over than 10 miles (16 km) per week or spend over 3 hours per week in comparable physical activity

Is there a sport you would say is your main sport

Over the last three months, on average how many times per week do you wash you hair with products (e.g. shampoo and/or conditioner)?

	0	2	4	6	8	10	12	14	16	18	20
Hair washes per week											

What hair products do you use when washing your hair? (type and brand)

Have you dyed your hair, bleached your hair, or had highlights? If, yes please provide details (type and brand) and the date of when you had this done (DD-MM-YYYY).

- ○ Yes
- ○ No

Do you use any hair products on a regular basis? If, yes please provide details (type and brand).

- ○ ____________ Yes
- ○ No

Considering the past three months, on average how many times per week do you use these products?

	0	2	4	6	8	10	12	14	16	18	20
Product use per week											

Considering the past three months, on average how many hours per day do you spend outdoors?

	0	2	5	7	10	12	14	17	19	22	24
Hours											

Considering the past three months, of these hours, how many do you cover your head with a hat, cap, helmet or other head covering?

	0	2	5	7	10	12	14	17	19	22	24
Hours											

Considering the past three months, have you used a sunbed?

- ○ Yes, please describe how many times you have used the sunbed and average minutes per sunbed ____________
- ○ No

Considering the past three months, have you travelled abroad?

- ○ Yes, please name the location and how long you stayed. ____________
- ○ No

Have you washed your hair today?

- Yes
- No

Have you exercised today?

- Yes
- No

Have you washed your hair since you exercised today?

- Yes
- No

Have you used any hair products today?

- Yes, please provide details (type and brand).
- No

Are you currently taking any medication?

- Yes, please provide the details of the medication you are currently taking
- No

What is your sex?

- Man
- Woman
- Other
- Would rather not say

At present, which statement best describes your menstrual cycle?

- ○ I have regular periods
- ○ I have periods but my periods are irregular
- ○ I do not have periods

What was the date of the start of your most recent period? (dd/mm/yyyy)

My periods have stopped due to...

- ○ Menopause
- ○ Surgery
- ○ Contraception e.g. pill/patch/injection/implant/IUD
- ○ Athletic amenorrhoea
- ○ Unknown
- ○ Other, please specify

Are you using the oral contraceptive pill/ contraceptive patch/injection/implant/intrauterine system?

- ○ Yes
- ○ No

Please specify which and give details (e.g. brand name)

Has your contraception changed within the last 6 months?

- Yes
- No

Do you know the duration of your menstrual cycle (the time from the start of one period to the start of your next period)?

- Yes
- No

Please estimate the approximate duration of your menstrual cycle (the time from the start of one period to the start of your next period)?

- Once every 20 days or less
- Every 21-27 days
- Every 28-35 days
- Every 36-50 days
- Every 3 -4 months
- Very irregular, sometimes monthly, sometimes skip several months
- __________ Other, please specify

11 Chapter 4 Additional Questionaires

11.1 Italian Life Orientation - Revised

LOT-R in Italian

Citation: Monzani, D., Steca, P., & Greco, A. (2014). Brief report: Assessing dispositional optimism in adolescence - Factor structure and concurrent validity of the Life Orientation Test - Revised. Journal of Adolescence, 37, 97-101.

Per ciascuna delle affermazioni che seguono, valuti il suo grado di accordo/disaccordo su una scala da 1 (massimo disaccordo) a 5 (massimo accordo) mettendo una crocetta negli appositi spazi. Legga attentamente le affermazioni, e cerchi di rispondere con la massima sinceritá, senza lasciarsi influenzare dalle sue risposte precedenti, n� da quello che reputa sia la valutazione della maggior parte delle persone. Tenga presente che non ci sono risposte giuste o sbagliate. La ringraziamo per la collaborazione.

1. Nei momenti difficili mi aspetto che tutto vada per il meglio
2. Mi riesce facile rilassarmi
3. Se qualcosa può andare per me per il verso sbagliato, sicuramente ci andrá
4. Sono sempre ottimista riguardo il mio futuro
5. Traggo molta soddisfazione dallo stare con i miei amici
6. Per me � importante avere sempre molte cose da fare
7. Quasi mai mi aspetto che le cose vadano per il meglio
8. Non mi infastidisco troppo facilmente
9. Raramente faccio affidamento sulla possibilitá che mi possano capitare cose positive
10. In generale mi aspetto che mi accadranno più cose positive che negative

http://local.psy.miami.edu/faculty/ccarver/sclItalianLOT.html

11.2 Italian Toronto Alexithymia Scale

TAS – 20

Toronto Alexithymia Scale

G.J. TAYLOR, R.M. BAGBY, J.D.A. PARKER, 1992

Seguendo le istruzioni sotto elencate indichi quanto è d’accordo o no con ciascuna delle seguenti affermazioni segnando una **x** sopra il numero corrispondente.

Segnare una sola risposta per ciascuna frase.

1 = NON SONO PER NIENTE D’ACCORDO
2 = NON SONO MOLTO D’ACCORDO
3 = NON SONO NÉ D’ACCORDO NÉ IN DISACCORDO
4 = SONO D’ACCORDO IN PARTE
5 = SONO COMPLETAMENTE D’ACCORDO

1.	Sono spesso confuso/a circa le emozioni che provo	1	2	3	4	5
2.	Mi è difficile trovare le parole giuste per esprimere i miei sentimenti	1	2	3	4	5
3.	Provo delle sensazioni fisiche che neanche i medici capiscono	1	2	3	4	5
4.	Riesco facilmente a descrivere i miei sentimenti	1	2	3	4	5
5.	Preferisco approfondire i miei problemi piuttosto che descriverli semplicemente	1	2	3	4	5
6.	Quando sono sconvolto/a non so se sono triste, spaventato/a o arrabbiato/a	1	2	3	4	5
7.	Sono spesso disorientato dalle sensazioni che provo nel mio corpo	1	2	3	4	5
8.	Preferisco lasciare che le cose seguano il loro corso piuttosto che capire perché sono andate in quel modo	1	2	3	4	5
9.	Provo sentimenti che non riesco proprio ad identificare	1	2	3	4	5
10.	È essenziale conoscere le proprie emozioni	1	2	3	4	5
11.	Mi è difficile descrivere ciò che provo per gli altri	1	2	3	4	5
12.	Gli altri mi chiedono di parlare di più dei miei sentimenti	1	2	3	4	5
13.	Non capisco cosa stia accadendo dentro di me	1	2	3	4	5
14.	Spesso non so perché mi arrabbio	1	2	3	4	5
15.	Con le persone preferisco parlare di cose di tutti i giorni piuttosto che delle loro emozioni	1	2	3	4	5
16.	Preferisco vedere spettacoli leggeri, piuttosto che spettacoli a sfondo psicologico	1	2	3	4	5
17.	Mi è difficile rivelare i sentimenti più profondi anche ad amici più intimi	1	2	3	4	5
18.	Riesco a sentirmi vicino ad una persona, anche se ci capita di stare in silenzio	1	2	3	4	5
19.	Trovo che l’esame dei miei sentimenti mi serve a risolvere i miei problemi personali	1	2	3	4	5
20.	Cercare significati nascosti in films o commedie distoglie dal piacere dello spettacolo	1	2	3	4	5

11.3 Recovery and Stress questionaire for Athletes (RESTQ-36-R-Sport) italian and english

Negli ultimi (3) giorni/notti

1) ... ho dormito poco / I did not get enough sleep

0	1	2	3	4	5	6
mai	raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

2) ... ho portato a termine compiti importanti / I finished important tasks

0	1	2	3	4	5	6
mai	raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

3) ... ero incapace di concentrarmi/ was unable to concentrate well

0	1	2	3	4	5	6
mai	raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

4) ... ero irritabile / Everything bothered me

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

5) ... ho riso / I laughed

0	1	2	3	4	5	6
Mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

6) ... ho provato fastidi fisici / I felt physically bad

0	1	2	3	4	5	6
Mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

7) ... ero di malumore / I was in a bad mood

0	1	2	3	4	5	6
Mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

8) ... mi sentivo fisicamente rilassato / I felt physically relaxed

0	1	2	3	4	5	6
Mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

9) ... ero di spirito buono / I was in good spirits

0	1	2	3	4	5	6
Mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

10) ... ho avuto difficoltà di concentrazione / I had difficulties in concentrating

0	1	2	3	4	5	6
Mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

11) ... ero preoccupato da problemi irrisolti / I worried about unresolved problems

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

12) ... mi sentivo a mio agio / I felt at ease

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

13) ... ho passato bei momenti con gli amici / I had a good time with my friends

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

14) ... ho avuto mal di testa / I had a headache

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

15) ... ero stanco dal lavoro fatto / I was tired from work

0	1	2	3	4	5	6
Mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

16) ... ho avuto successo in quello che ho fatto / I was successful in what I did

0	1	2	3	4	5	6
Mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

17) ... non potevo smettere di pensare / I couldn't switch my mind off

0	1	2	3	4	5	6
Mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

18) ... Mi sono addormentato soddisfatto e rilassato / I fell asleep satisfied and relaxed

0	1	2	3	4	5	6
Mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

19) ... mi sono sentito fisicamente male / I felt uncomfortable

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

20) ... mi sono sentito irritato dagli altri / I was annoyed by others

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

21) ... mi sono sentito abbattuto / I felt down

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

22) ... mi sono trovato con amici / I visited some close friends

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	Sempre

23) ... mi sono sentito depresso / I felt depressed

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	Sempre

24) ... ero stanco morto dopo il lavoro / I was dead tired after work

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	Sempre

25) ... gli altri mi davano sui nervi / Other people got on my nerves

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	Sempre

26) ... ho avuto un sonno riposante/ I had a satisfying sleep

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

27) ... ero ansioso e bloccato / I felt anxious or inhibited

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

28) ... mi sono sentito fisicamente in forma / I felt physically fit

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

29) ... ero stanco di tutto / I was fed up with everything

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

30) ... ero apatico / I was lethargic

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

31) ... mi sono sentito di dover far bene di fronte agli altri / I felt I had to perform well in front of others

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

32) ... mi sono divertito / I had fun

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

33) ... ero di buon umore / I was in a good mood

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

34) ... ero sfinito / I was overtired

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

35) ... ho avuto un sonno agitato / I slept restlessly

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

36) ... ero arrabbiato/ I was annoyed

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

37) ... mi sono sentito efficace/ I felt as if I could get everything done

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

38) ... ero adirato/ I was upset

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

39) ... ho rimandato la presa di decisioni/ I put off making decisions

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

40) ... ho preso importanti decisioni/ I made important decisions

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

41) ... mi sono sentito fisicamente esausto/ I felt physically exhausted

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

42) ... ero felice/ I felt happy

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

43) ... mi sono sentito sotto pressione/ I felt under pressure

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

44) ... non ne potevo più/ Everything was too much for me

4	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

45) ... mi sono svegliato di notte senza motivo/ My sleep was interrupted easily

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

47) ... ero contento/ I felt content

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

48) ... ero arrabbiato con altri/ I was angry with someone

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

49) ... ho avuto delle buone idee/ I had some good ideas

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

50) ... mi facevano male alcune parti del corpo/ Parts of my body were aching

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

51) ... non sono riuscito a riposarmi durante le pause/ I could not get rest during breaks

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

52) ... ero convinto di poter raggiungere facilmente gli obiettivi stabiliti/ I was convinced I could achieve my set goals during performance

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

53) ... ho potuto recuperare bene fisicamente / I recovered well physically

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

54) ... mi sentivo esausto per la mia attività sportiva/ I felt burned out by my sport

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

55) ... ho raggiunto molte soddisfazioni nel mio sport / I accomplished many worthwhile things in my sport

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

56) ... mi sono potuto preparare mentalmente per la mia prestazione/ I prepared myself mentally for performance

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

57) ... i miei muscoli erano rigidi e tesi durante la prestazione / My muscles felt stiff or tense during performance

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

58) ... ho avuto l’impressione che ci fossero troppo poche pause / I had the impression there were too few breaks

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

59) ... ero convinto di poter fare la mia prestazione in qualsiasi momento / I was convinced that I could achieve my performance at any time

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	Spesso	Molto spesso	Quasi sempre	sempre

60) ... sono stato in grado di affrontare efficacemente i problemi coi miei compagni di squadra /

0	1	2	3	4	5	6

mai Raramente Qualche volta Spesso Molto spesso Quasi sempre sempre

61) ... ero in buona condizione fisica / I was in a good condition physically

0 1 2 3 4 5 6
mai Raramente Qualche volta Spesso Molto spesso Quasi sempre sempre

62) ... sono stato in grado di motivarmi da solo durante la mia prestazione/ I pushed myself during performance

0 1 2 3 4 5 6
mai Raramente Qualche volta Spesso Molto spesso Quasi sempre sempre

63) ... mi sono sentito emotivamente esaurito per la prestazione/ I felt emotionally drained from performance

0 1 2 3 4 5 6
mai Raramente Qualche volta Spesso Molto spesso Quasi sempre sempre

64) ... avevo dolori muscolari dopo la prestazione / I had muscle pain after performance

0 1 2 3 4 5 6
mai Raramente Qualche volta Spesso Molto spesso Quasi sempre sempre

65) ... ero convinto di aver eseguito bene/ I was convinced that I performed well

0 1 2 3 4 5 6
mai Raramente Qualche volta Spesso Molto spesso Quasi sempre sempre

66) ... durante le pause mi era chiesto troppo/ Too much was demanded of me during the breaks

0 1 2 3 4 5 6
mai Raramente Qualche volta Spesso Molto spesso Quasi sempre sempre

67) ... ho saputo motivarmi al massimo prima della prestazione / I psyched myself up before performance

0 1 2 3 4 5 6
mai Raramente Qualche volta Spesso Molto spesso Quasi sempre sempre

68) ... ho pensato di abbandonare il mio sport / I felt that I wanted to quit my sport

0 1 2 3 4 5 6
mai Raramente Qualche volta Spesso Molto spesso Quasi sempre sempre

69) ... mi sentivo pieno di energia / I felt very energetic

0 1 2 3 4 5 6
mai Raramente Qualche volta Spesso Molto spesso Quasi sempre sempre

70) ... mi rendevo facilmente conto di come si sentivano i mie compagni di squadra/ I easily understood how my team-mates felt about things

0 1 2 3 4 5 6
mai Raramente Qualche volta Spesso Molto spesso Quasi sempre sempre

71) ... ero convinto di essermi allenato bene / I was convinced that I had trained well

0 1 2 3 4 5 6
mai Raramente Qualche volta Spesso Molto spesso Quasi sempre sempre

72) ... le pause erano nel momento sbagliato / The breaks were not at the right times

0 1 2 3 4 5 6
mai Raramente Qualche volta Spesso Molto spesso Quasi sempre sempre

73) ... ero vulnerabile agli infortuni / I felt vulnerable to injuries

0 1 2 3 4 5 6
mai Raramente Qualche volta spesso Molto spesso Quasi sempre sempre

74) ... ho stabilito obiettivi precisi per la mia prestazione / I set definite goals for myself during performance

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	spesso	Molto spesso	Quasi sempre	sempre

75) ... mi sentivo fisicamente forte / My body felt strong

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	spesso	Molto spesso	Quasi sempre	sempre

76) ... mi sentivo frustrato dal mio sport / I felt frustrated by my sport

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	spesso	Molto spesso	Quasi sempre	sempre

77) ... ho affrontato problemi emotivi nel mio sport con molta calma / I deal with emotional problems in my sport very calmly

0	1	2	3	4	5	6
mai	Raramente	Qualche volta	spesso	Molto spesso	Quasi sempre	sempre