The development of a questionnaire to assess training and match demand in adolescent cricketers

Nico Grobler

(Student number: 2631174)

A dissertation submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for the degree of Master of Science in Medicine.

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Declaration

I, Nico Grobler, declare this dissertation is my own unaided work. It is being submitted for the degree of Master of Science in Medicine at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

Nico Grobler

Name of candidate Signature of candidate

9th day of May 2024 in Pretoria

Faculty of Health Sciences, Postgraduate Office
Phillip V Tobias Building, 2nd Floor
Cnr York & Princess of Wales Terrace, Parktown 2193
Tel: (011) 717 2745 | Fax: (011) 717 2119
Email: Mathoto.senamela@wits.ac.za

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Dedication

In humble gratitude to the Lord, whose grace guides my steps and blesses my journey with unwavering faith.

To the pillars of my life, my father, mother, and brother, your unwavering love and support illuminated my path.

Presentations arising from this Study

This study will be presented as an e-poster at the 7th IOC World Conference on Prevention of Injury and Illness in Sport, held in Monaco from 29 February to 2 March 2024.

Abstract

Background: Recording training and match demand in adolescent sports is essential in preventing overtraining and injuries while ensuring optimal performance and well-being. The study aimed to develop a valid and reliable questionnaire that would measure the training and match the demands of adolescent cricketers.

Methods: In Study 1, the content validity of the training and match demand questionnaire was measured using the content validity index, while the reliability was measured using Kendall's coefficient of concordance (Kendall' W).

In Study 2, a pilot study was performed using the questionnaire developed in Study 1. Daily training and match demand for all activities done in cricket (i.e., bowling, batting, fielding, strength and conditioning) and any other sport or activities were recorded in 17 adolescent cricketers. Acute:Chronic workload ratios (ACWR) were determined for all activities.

Results: The developed questionnaire was deemed valid (I-CVI score of 0.83) and reliable (Kendall's W score of 0.63). Over the 7-week period, some spikes in the acute training and match demand were observed. However, the overall ACWR was within the norms (0.8-1.3). Bowling reported an average ACWR of 0.91; other sports reported the highest average of 1.08, while the average for all activities combined was 0.92.

Conclusion: The questionnaire measured the training and match demand of the cricketer over time and can be used as a valuable tool in future research and practice in adolescent cricket.

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List of Abbreviations

RPE – Rating of perceived exertion

sRPE – Session rating of perceived exertion

ACWR – Acute:Chronic workload ratio

EWMA model – Exponentially weight moving average model

RA – Rolling average model

ACSM – American Counsel of Sports Medicine

HRmax – Maximum heart rate

VO2max – Maximum oxygen consumption

GPS – Global positioning system

VBT – Velocity based training

Part – Participant

SAQ – Speed, agility and quickness

MLB – Major League Baseball

Operational Definitions

Absolute intensity: “Exercise intensity independent of an individual's physical capacity (e.g., absolute internal intensity: $\dot{V}$ O2; absolute external intensity: running speed)” (Staunton et al., 2021, p. 442).

Adaptation: “The change process in the physical and physiological systems in response to exercise” (Staunton et al., 2021, p. 442). “With adaptation, the body will positively adapt to each acute exercise variable” (Staunton et al., 2021, p. 442). “The body negatively adapts to maladaptation due to fatigue and overtraining” (Staunton et al., 2021, p. 442).

Exercise demand: “The product of frequency, duration and intensity” (Constable et al., 2021, p. 2). “Quantification can be done over a session, week, season, or career” (Constable et al., 2021, p. 2). It more accurately describes volume within a cricket context (Constable et al., 2021).

Exercise intensity: “The specific level of muscular activity can be quantified regarding power (rate of energy expenditure), force, or velocity” (Winter & Fowler, 2009, p. 449). “Exercise intensity can be quantified in absolute and relative terms and measured in internal or external units (e.g., external = locomotor and mechanical; internal = physiological)” (Winter & Fowler, 2009, p. 449).

Exercise volume: “The product of exercise intensity, time and frequency” (Pescatello et al., 2014, p. 230).

Frequency: “The number of exercise or training sessions per day, week or month” (Pescatello et al., 2014, p. 230).

Load (N): Implies that resistance was encountered while carrying out the task (Staunton et al., 2021).

Progression: “The advancement of the exercise program through a gradual increase in exercise volume/intensity” (Bushman, 2018, p. 7). “This is achieved by adjusting exercise duration, frequency and/or intensity until the desired exercise goal is reached" (Bushman, 2018, p. 7).

Relative intensity: "Exercise intensity specific to the individual's physical capacity (e.g., Relative Internal Intensity: % HRmax, % $\dot{V}$ O2max; relative external intensity: % maximum running speed)" (Staunton et al., 2021, p. 442).

Type: "The exercise session duration or match" (Pescatello et al., 2014, p. 230).

Work (J): "Implies that mechanical work was accomplished" (Staunton et al., 2021, p. 442).

Chapter 1 Introduction

1.1 Background

The popularity of cricket is increasing across all levels of participation in most cricket-playing nations (Pote & Christie, 2019). This change can be attributed to several factors, including its rich history, diverse playing formats, international competitions, legendary players, and widespread accessibility through broadcasts and digital platforms (Pote & Christie, 2019).

The introduction of different match formats, for example, day and night test matches (first played in 2015 between Australia and New Zealand) and traditional test matches (first played in 1877 between England and Australia), offer a strategic experience over five days (ESPN Cricinfo, 2006). Explosive One Day Internationals (ODIs) (first played in 1972 between Australia and England) bring excitement with a limit of 50overs. The exciting and fast-paced entertainment of Twenty20 (T20) matches with a limit of 20 overs (first played in June 2003 between two English County teams, Surrey Lions and Warwickshire Bears (ESPN Cricinfo, 2006)) have all played a significant role in the rise in the popularity of cricket worldwide (Christie et al., 2020). Cricket is a unique sport that involves both individual and team-based gameplay (Bourdon et al., 2017). Although it is primarily a team sport where two teams compete against each other, the contributions and performances of individuals can significantly influence the game's outcome (Bourdon et al., 2017).

From a biomechanical standpoint, cricket shares elements of running, sprinting, standing, diving, throwing, catching, and striking an object at different intervals and speeds, which are also required by many other similar sports (Christie et al., 2020). The range of physical qualities required varies considerably in cricket, so successful planning and programming for individual and team performance is a fundamental aspect of coaching to help the players cope with the increased physical demands of professional cricket (Pote & Christie, 2019). One can, therefore, assume that with the correct planning and programming in place, individual and team performance will be consistent week in and week out, and the likelihood of injuries will be reduced (Bourdon et al., 2017).

Training is a process that focuses on developing the motor skills and physical fitness of individuals (Doe-Asinyo & Smits-Engelsman, 2021), intending to improve their performance or that of a team by modifying the exercise demand through changes in training frequency, intensity, and/or duration (Black et al., 2016). To ensure that athletes do not experience non-functional overreaching, injury, or illness, it is important to monitor their physiological responses to changes in exercise demand and assess their need for recovery (Constable et al., 2021). This is achieved through monitoring training and match demand, which has recently gained popularity due to its role in providing data to inform future decisions about general and sport-specific training (Murray, 2018).

Surprisingly, few studies are available that discuss monitoring training and match demand in team sports such as cricket despite the reduced injury risk and improved performance that this monitoring provides (Goggins et al., 2021). Research has shown that the prevalence of injuries, especially in fast bowlers, is as high as in individuals playing contact sports such as rugby and soccer (Forrest et al., 2018). There is little research demonstrating the demands of other playing positions, although increased injury risk in elite athletes has been linked to higher throwing volumes (Saw et al., 2010). According to Saw et al. (2010), cricketers who complete more than 75 throws per week with fewer rest days in the previous week have a higher risk of upper limb injuries. Therefore, it is important to monitor all aspects of cricket to prevent such injuries (Saw et al., 2010).

In South Africa, cricket has developed tremendously over the past few years, which has resulted in longer, arduous seasons (Pote & Christie, 2019). As a result of this, the level of competition both within and between teams has risen drastically, which, in turn, has resulted in early specialisation in cricket (Pote & Christie, 2019). In parallel to these changes, longer and highly condensed cricket seasons, the change in game formats, and more explosive play styles have increased the physical demands placed on players (Forrest et al., 2018). This has resulted in a subsequent increase in the number and severity of reported injuries (Forrest et al., 2018). At the same time, the demands of other sporting codes have also increased. Most adolescent cricketers participate in multiple sports, which, in light of the previously mentioned developments, has resulted in an overall increase in training demand and injury risk (Griffen et al., 2020).

When working with young athletes, scheduling and regulating suitable training and match demand is important (Murray, 2018). There is a high correlation between training volumes and injuries if this balance is not achieved (Pote & Christie, 2019). Despite this, few studies describe how the high demands of participation in multiple sports disciplines, school requirements, and social life impact the performance of adolescent cricket players (Pote & Christie, 2019).

There are various ways to measure training and match demand. Most are either very expensive (e.g. Global Positioning Systems (GPS), force plate measuring systems, and heart rate (HR) monitors) or lack reliability and validity (e.g. non-standardised questionnaires). While some (GPS, force plate measuring systems, and HR monitors) may be impractical to implement in an adolescent setting, self-reported questionnaires have been well-researched and can be used as an effective method to measure training and match demand in sports (Borresen & Lambert, 2009). Questionnaires to assess the impact of participation in multiple sports disciplines, school requirements, and social life on adolescent athletes are available, but not specifically validated for use in the context of adolescent cricket in South Africa. Validated questionnaires addressing the unique demands placed on adolescent cricketers are needed to better understand and support their performance.

The current questionnaires contain confusing terminology that has not been standardised and may need to be simplified to understand or accurately complete. Staunton et al. (2021) and Constable et al. (2022) have explored the most suitable terminology to describe the level of training required in cricket; their findings suggest that using terms like "demand", "volume", or "intensity" can be more effective than terms like "work", "training load", or "player load". By correctly utilising these terms, communication within the sport and the literature will be more transparent and precise.

Social and lifestyle factors such as family support, peer relationships, nutrition, and overall mental and physical health should also be considered when working with young athletes (Pretorius et al., 2022). External influences unrelated to training or competitions may also contribute to high-stress levels, resulting in decreased sports performance and an increased risk of injury.

The multidimensionality of factors influencing injury risk and athletic performance necessitates a comprehensive monitoring approach for young athletes. Such an approach can provide them with the optimal environment to perform at their best, minimise their risk of injury, and ensure long-term participation in their chosen sport. Furthermore, implementing interventions that foster enjoyment and a positive experience may reinforce participation and engagement. Therefore, it is imperative to leverage a multidisciplinary approach in monitoring young athletes, which addresses physical, psychological, and social factors to promote optimal performance and well-being.

1.2 Problem Statement

Monitoring training and match demand in sports is important to optimise performance and minimise the risk of injury. Elite athletes and sports teams employ various techniques to track and analyse the physical and physiological demands placed on athletes during training and competition. There are multiple ways to measure training and match demand, and most are either very expensive (e.g., Global Positioning Systems (GPS) monitors, force plate measuring systems, and heart rate monitors) or need better reliability and validity (e.g., non-standardised questionnaires).

The cost, expertise, and time required to interpret the results of GPS monitors, force plate measuring systems, and heart rate monitors can be impractical to implement in an adolescent setting. Therefore, in order to allow monitoring in the adolescent setting where these methods may not be viable or available, there is a need for an alternative solution. Self-reporting questionnaires have been extensively studied and proven effective for measuring training and match demand in sports. However, existing tools have not been validated for use in cricket or with adolescent athletes. Additionally, these questionnaires use terminology that is not suitable for adolescent cricket. In some instances, the methods used to measure the Acute:Chronic workload ratios (ACWR) are inaccurate or show no correlation (Menaspa, 2016.). Furthermore, the available tools do not consider the impact of multiple factors, such as performance in multiple sporting codes, school commitments, and social life on cricket and sports.

Current mainstream research is focused on elite-level cricketers and mainly on elite-level bowlers, while only some have looked at the training and match demand placed on adolescent cricketers. Research has provided specific bowling guidelines for adolescent cricketers for the recommended maximum number of deliveries allowed per training or innings in a match (Cricket Australia, 2023). However, more research is needed on specific guidelines for the different playing positions in cricket and the effect of additional training and match demands of other sports on adolescent cricketers. Suppose overall training and match demand is not optimally balanced with the need for recovery. In that case, it may result in a high injury rate, poor cricket and other sports performance, burn-out, or a complete end to sports participation. To address this problem, there needs to be an effective tool, accessible to all adolescent cricketers, that is cost-effective and can help to accurately measure overtraining and match demand, prevent injuries, and ensure long-term participation.

1.3 Aim and Objectives

This study aimed to develop a valid and reliable questionnaire to monitor the training and match demand in adolescent cricketers.

The objectives of the study were to:

1. Develop a training and match demand questionnaire and assess the content, face validity, and test-retest reliability in adolescent cricket (Study 1).
2. Assess training and match demand by determining the total time spent on the different aspects associated with cricket (bowling, batting, fielding, strength and conditioning) and the number of deliveries bowled, the number of balls faced in a batting session, the total number of balls thrown in a fielding session as well as any other training sessions attended over a 7-week period (Study 2).
3. Assess training and match demand by determining the rating of perceived exertion (RPE) and ACWR for all the different aspects associated with cricket, as well as any other training sessions done over a 7-week period (Study 2).

1.4 Significance

To ensure the safety and well-being of adolescent cricket players, coaches and sports coordinators require a reliable and valid questionnaire to monitor training and match demands. This tool provides valuable insight into the demands placed on these adolescent athletes, allowing coaches and coordinators to take early action and prevent injuries and burn-out. While different methods for measuring external and internal demand have been extensively researched (French et al., 2022), budget constraints prevent many school coaches and conditioning staff from implementing costly techniques. There is a pressing need to find effective and affordable ways to measure training and match demand across all sports. The questionnaire used in cricket can be adapted and validated for other sports, providing a valuable resource for coaches and coordinators seeking to protect the health and well-being of their athletes.

1.5 Outline of this Dissertation

The outline of this dissertation is shown in Figure 1. Chapter 1 introduces monitoring training and match demand in adolescent cricketers and the problem statement, aim, objectives and significance. Chapter 2 provides a comprehensive literature review, highlighting the importance of monitoring training and match demand, the problems associated with monitoring training and match demand in adolescents and the best way to monitor training and match demand in adolescents. Chapter 3 provides the methods and results of the validity and reliability process of the developed questionnaire to monitor training and match demand in adolescents. Chapter 4 provides the pilot study's methods and results to monitor adolescent cricketers' training and match demands. Chapter 5 discusses studies 1 (chapter 3) and 2 (chapter 4). Chapter 6 provides the research's conclusion, strengths and weaknesses and recommendations for coaches and future researchers.

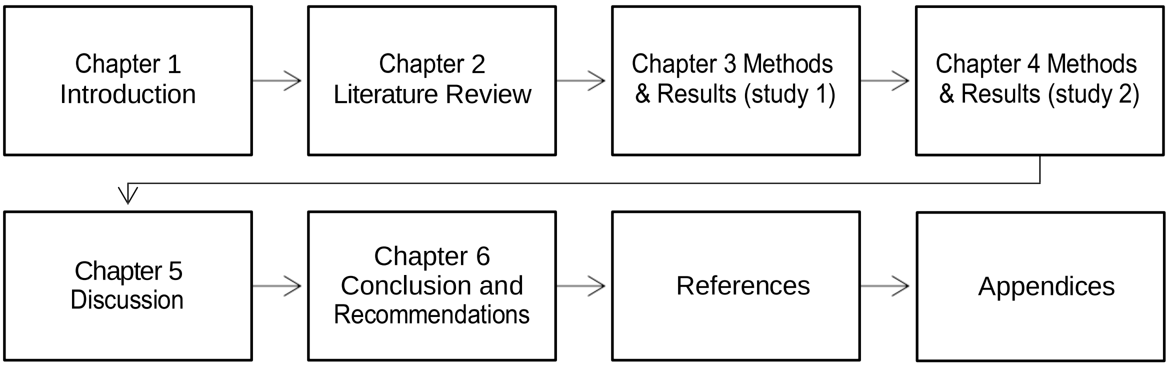

Figure 1. Outline of the dissertation

Chapter 2 Literature Review

2.1 Introduction

Alongside the rise in the popularity of cricket at a senior level, there has been a notable rise at the adolescent level (Forrest et al., 2020). This has increased the demand to perform at an optimal level week in and week out, which increases the daily strain placed on individual players (Forrest et al., 2020). Other adolescent sports have also become more specialised, and with most adolescent players practising more than one sport in a season, the overall demand on individuals has increased (Forrest et al., 2020). It is important to monitor their training and match demand to prevent high rates of injury, underperformance, burnout, or even discontinuation of sports participation.

This literature review discusses the importance of monitoring training and match demand in adolescent cricket. It is presented under several subheadings, including the prevalence of injuries in adolescent cricket, monitoring training and match demand, external and internal training and match demand, and more. The review highlights the current confusion regarding terminology and stresses the importance of using the correct terms to describe exercise. It further explores the difference between external and internal training and match demand and the different measuring methods. The review also examines the ACWR, which tracks training changes and match demand over time. It discusses the models used to calculate the ACWR and how it can be applied in monitoring training and match demand in adolescent cricket. Overall, the literature review emphasises proper monitoring and management of training and match demand to prevent injuries and improve performance in adolescent cricket.

Evidence was sourced from online sports medicine and science literature databases, including PubMed, CINAHL, SPORTDiscus, SCOUPUS, EMBASE, and Google Scholar, as well as articles published until December 2023. Keywords searched included: ‘cricket injuries’, ‘quantification of training load’, ‘quantify exercise intensity’, ‘workload’ ‘work load’, Acute:Chronic workload ratio’ exponentially weighted moving average’, ‘session RPE’ and ‘external, internal workload’, limited to English papers and human subjects.

2.2 The prevalence of injuries in adolescent cricket

The prevalence of injuries among adolescent cricketers has garnered significant attention and concern. This is a well-researched topic that has received attention from local researchers (Trellar et al., 2012 & Stretch, 2014) and international researchers (Killian et al., 2006). Adolescent cricketers are more at risk of sustaining an injury and a recurrence of that injury compared to elite cricket players (Milson et al., 2007). These injuries can range from minor ligament sprains and muscle and tendon strains to more severe lower back fractures, shoulder or finger dislocations, or concussions (Stretch, 2014).

Typical rapid changes in physical development in adolescents may contribute to a higher risk of injuries when engaged in the dynamic and physically demanding game of cricket (Pardiwala et al., 2017). Factors such as inadequate warm-up or cool-down routines, improper technique execution and insufficient rest and recovery periods can increase the likelihood of injuries (Pardiwala et al., 2017).

Common cricket-related injuries among adolescent players include muscle strains, ligament sprains, tendinopathy, stress fractures, and injuries to the fingers, hands, or head (Finch, et al., 1999). Fast bowlers may be prone to lower back injuries or shoulder problems due to the repetitive nature of their bowling action (Stretch et al., 2005). Batters may experience injuries from impact with the ball, such as bruising or fractures, while fielders may encounter injuries from diving and awkward landings (Forrest, 2018).

In a 5-year retrospective study, Stretch (2014) reported an injury incidence of 29%-36% in adolescent cricketers (15-18 years old). These injuries were predominantly to the lower limbs (38%), torso and back (33%), and upper limbs (26%). A similar number of injuries occurred between matches (30%) and practice (29%). Most injuries happened during the in-season (63%) compared to the off-season (15%). The leading cause of injuries were bowling (48%) and fielding (30%). The significantly greater number of injuries in-season may be due to high training and match demand, which can lead to overuse injuries, or low training and match demand during the off-season, which will not adequately prepare the cricketer for the demands of the cricket season.

Vigilant monitoring of adolescent cricketers' training and match demands is important to prevent injuries (Finch et al., 1999). To achieve this, injury prevention strategies should be given priority, including the implementation of warm-up and stretching routines, educating players on proper techniques and mechanics, ensuring adequate rest and recovery periods, promoting good nutrition and hydration, and providing suitable protective gear (Meyers et al., 2001). Monitoring the training and match demands can assist in tracking the effectiveness of these strategies and ultimately help reduce the incidence of injuries.

2.3 Monitoring training and match demand

Sports success depends on balancing competitive demands and effective training strategies. Training (Figure 2) and match demand (Figure 3) refer to the specific requirements and challenges athletes face during competitive matches and structured training sessions (French et al., 2022). Both types of demand are essential in sports performance, and coaches and athletes must customise their preparation to meet these distinct but interconnected requirements while minimising the risk of injury and burnout (French et al., 2022).

Training demand (Figure 2) refers to athletes' physical and mental requirements during training sessions (French et al., 2022). Coaches and sports scientists must consider training demand as a crucial factor when designing training programs, as it helps to optimise athletes' development while minimising the possibility of injury and burnout (French et al., 2022).

Periodisation (Figure 2) is a fundamental training concept that involves dividing a season or year into smaller, more manageable periods (French et al., 2022). The macrocycle, which encompasses the overarching plan for the entire season, determines general objectives, outlines competition periods, and specifies each training phase's focus (French et al., 2022). The mesocycle, typically lasting for several weeks to several months, is a medium-range plan that targets specific aspects of performance, such as strength, speed, or skill development (French et al., 2022). Finally, the microcycle lasts for a week and is a short-term plan that provides detailed information on daily training sessions, recovery periods, and rest days. By breaking down the training process into smaller cycles, athletes can better manage their progress and ensure that they are making steady improvements over time (French et al., 2022). Periodisation is a practical approach in athletic training, enabling athletes to optimise their performance and achieve their goals (French et al., 2022).

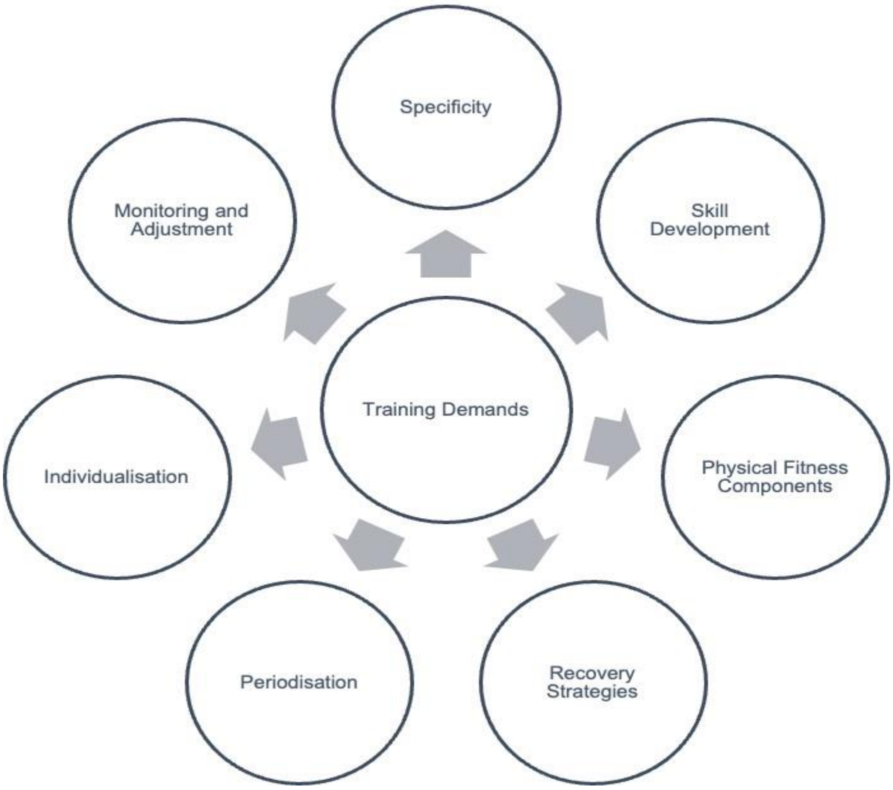

Figure 2. Training demands experience (French et al., 2022)

Athletes can enhance their abilities and achieve optimal performance by focusing on developing specific skills (Figure 2) and movements essential for their sport (Abraham & Collins, 2011). This requires targeted training and coordination practices to help them gain a competitive edge over their peers (Abraham & Collins, 2011). Efficient and productive training requires understanding critical factors such as variability and adaptation. (Abraham & Collins, 2011).

Proper recovery strategies (Figure 2) are essential to optimise physical performance and reduce the risk of injury (French et al., 2022). Active recovery is a popular approach involving low-intensity activities to promote blood flow and reduce muscle soreness (French et al., 2022). In addition to functional recovery, regeneration techniques like massage, compression therapy, ice baths, and stretching have improved recovery by enhancing flexibility and reducing inflammation (French et al., 2022). Adequate rest and proper nutrition are also crucial to an effective recovery plan

(French et al., 2022). Getting enough sleep allows the body to repair and rebuild damaged tissues, while good nutrition provides the necessary nutrients to support recovery (French et al., 2022). A balanced diet with sufficient protein, carbohydrates, and healthy fats can help replenish energy stores and promote muscle repair. By implementing these recovery strategies, individuals can optimise their body's ability to recover from physical activity and perform at their best (French et al., 2022). It is important to note that recovery is a personalised process, and what works for one person may not work for another (French et al., 2022).

Individualisation (Figure 2) is a fundamental concept in athletic training that emphasises the need to tailor training programs to meet individual athletes' unique needs, capabilities, and performance goals (Abraham & Collins, 2011). This requires coaches and trainers to recognise that athletes have different physiological and psychological responses to training stimuli and to adjust their programs accordingly (Abraham & Collins, 2011). By doing so, coaches can optimise each athlete's performance while minimising the risk of injury (Abraham & Collins, 2011). Ultimately, individualisation is critical to helping athletes achieve their full potential safely and sustainably (Abraham & Collins, 2011).

Athletes are judged not only by their performance during training but also by their ability to deliver in competitions (French et al., 2022). The nature of each sport determines what we refer to as match demand (Figure 3), which is the unique characteristic of every sport that athletes must prepare for (French et al., 2022). Understanding and preparing for these specific competition demands is crucial for athletes and coaches (French et al., 2022). By dissecting match demand, we hope to help athletes and coaches better understand what it takes to excel in high-pressure situations and how to prepare for peak athletic performance (French et al., 2022).

The intensity (Figure 3) of competition is known to surpass that of training sessions (French et al., 2022). Athletes must perform at or near their peak capacity, which entails executing explosive movements, rapid speed changes, and dynamic physical efforts specific to their sport (French et al., 2022). The presence of spectators, the pressure to succeed, and the desire to outdo opponents make competitive matches an entirely different experience from training sessions (French et al., 2022). Thus, the intensity of competition demands a higher level of physical and mental preparation from athletes (French et al., 2022).

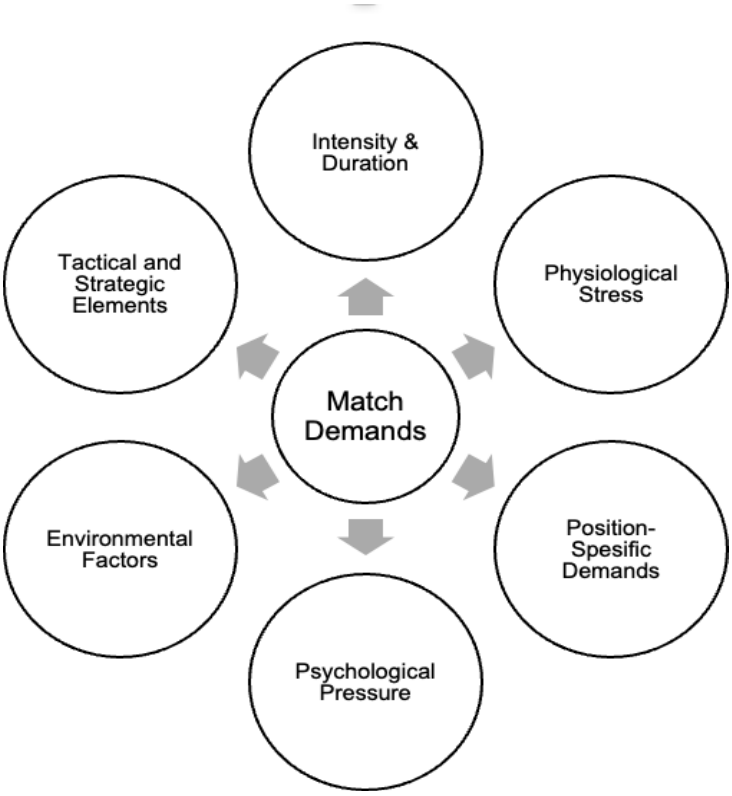

Figure 3. Match demand experienced (French et al., 2022)

A fundamental aspect of an athlete's preparation for competition involves understanding the matches' duration (Figure 3) (French et al., 2022). The temporal characteristics of different sports can vary widely, with some requiring short bursts of high-intensity activity while others involve longer, endurance-based events (French et al., 2022). As such, athletes must be aware of the specific duration of their matches to ensure that they can maintain optimal performance throughout (French et al., 2022). Developing the requisite endurance to sustain performance is critical, and athletes should tailor their training accordingly to meet the demands of their sport (French et al., 2022).

Interruptive periods of high-intensity exertion and lower-intensity activities are not uncommon (Figure 3). To sustain optimal performance throughout the match, athletes must carefully manage their energy levels and prioritise recovery during breaks within the competition (Doherty et al., 2021). The ability to recover efficiently and effectively is a crucial determinant of an athlete's performance and can significantly impact the match's outcome (Doherty et al., 2021). Proper recovery strategies during rest periods are paramount for athletes to perform at their best and succeed in their respective sports (Doherty et al., 2021). The recovery period following a match is of utmost importance for athletes (Doherty et al., 2021). They must engage in appropriate cool-down activities, receive any necessary medical attention, and prioritise rest to allow their bodies to recuperate from the physical strain of the match (Doherty et al., 2021). Adequate recovery can significantly reduce the risk of injury and enhance overall performance in subsequent matches (Doherty et al., 2021). Therefore, athletes must prioritise the recovery process and follow a well-designed recovery plan to optimise their performance.

Competitive sports can be mentally challenging (Figure 3), and athletes must navigate various psychological stressors to perform their best (Paul et al., 2023). The pressure to win, the stress of competition, and the need for strategic decision-making can significantly contribute to an athlete's overall match demand (Paul et al., 2023). Therefore, mental resilience is a crucial component of success in sports, allowing athletes to maintain their focus and composure despite intense pressure (Paul et al., 2023). Mental preparation is just as vital as physical training in sports performance. Psychological considerations are significant, especially in managing mental fatigue (Paul et al., 2023). Mental exhaustion can profoundly impact an athlete's physical abilities, so athletes must learn how to overcome this challenge (Paul et al., 2023). To do so, they must develop effective strategies that help them manage their mental state and optimise their performance (Paul et al., 2023).

It's important to note that every position in a sport has unique physical and strategic demands (Figure 3) during a match (Abraham & Collins, 2011). This means a bowler has different requirements than a fielder (Abraham & Collins, 2011). To ensure that you are fully prepared for a game, it's crucial to be aware of the specific demands of your position and train accordingly (Abraham & Collins, 2011). By doing so, you'll be able to perform at your best on the field and contribute to your team's success (Abraham & Collins, 2011).

Environmental factors (Figure 3) are crucial in athletes' performance during matches (Kuok & Daniel, 2021). The differences in temperature, altitude, or weather conditions in diverse settings can significantly affect an athlete's performance (Kuok & Daniel, 2021). Therefore, athletes must adapt to these environmental factors to perform their best during training (Kuok & Daniel, 2021). This adaptation can be achieved through various techniques, such as heat or altitude training, to enhance the body's physiological response to these environmental factors (Kuok & Daniel, 2021). By integrating these techniques into their training regimen, athletes can optimise their performance and prepare to face diverse ecological conditions during competitions (Kuok & Daniel, 2021).

Athletic performance is a complex process that requires athletes to effectively manage various physical, mental, tactical, and environmental factors during competitive events (French et al., 2022). This combination of demands is critical to understanding and preparing to optimise sports training and performance (French et al., 2022). By developing strategies to address these factors, athletes can enhance their ability to perform at their best and achieve their goals on the field (French et al., 2022).

Monitoring athletes primarily aims to gather valuable information that can effectively guide future training decisions and athletics performance (Figure 4) (French et al., 2022). This monitoring process allows the coach to understand better the intricate relationships between training, injury, illness, and performance outcomes (French et al., 2022). Regardless of the range of physical qualities required in each sport, the consistent goal of training is to progressively develop these qualities to enhance performance, and monitoring plays an important role in achieving this (French et al., 2022).

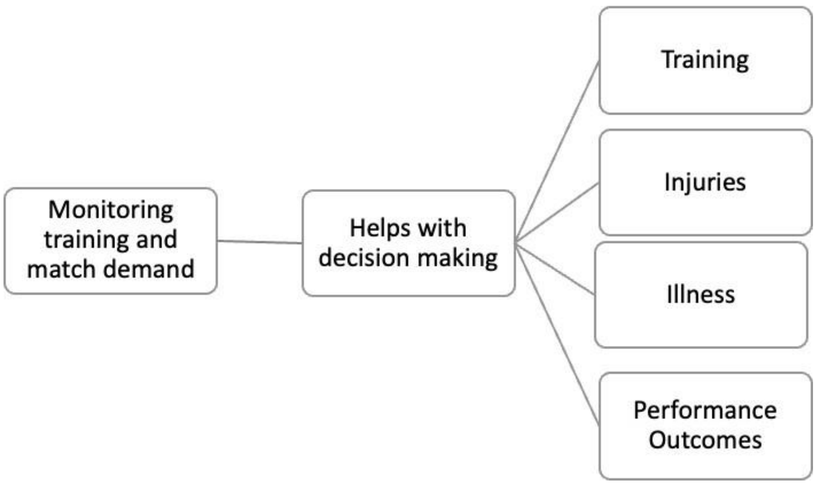

Figure 4. Decision-making process to guide future training (French et al., 2022)

To cause biological adaptation, the system's current capacity must be disturbed (Selye, 1956). This disturbance to homeostasis disrupts performance, causing fatigue (Cunanan et al., 2018). However, the body adapts and may improve performance due to a supercompensation effect (Cunanan et al., 2018). Selye's General Adaptation Syndrome describes this physiological pattern of a stress response (Figure 5, Selye, 1956, p.585), which provides a framework for the acute fatigue response, adaptation, and ultimately a new level of performance (Cunanan et al., 2018).

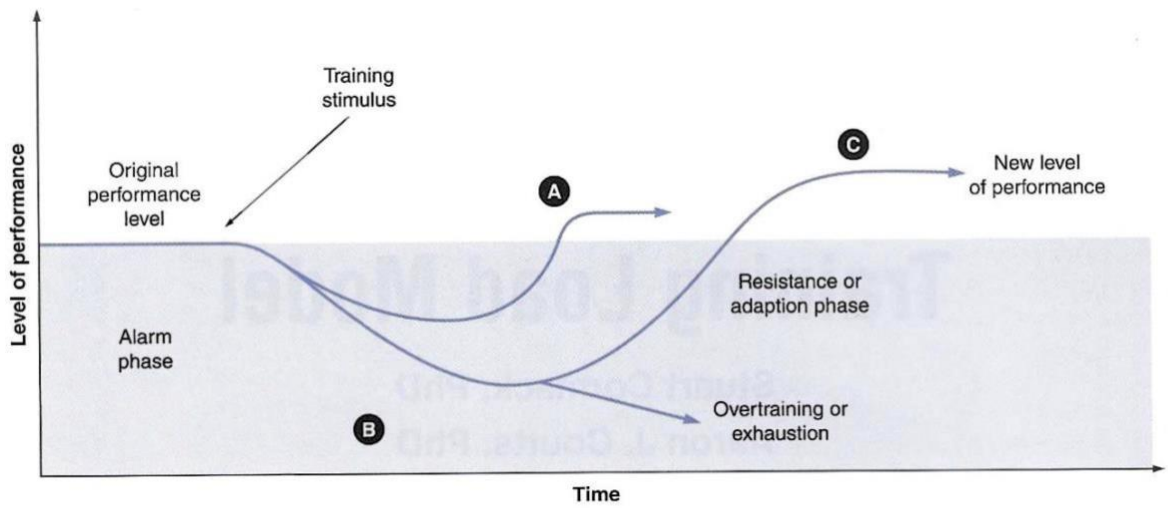

Figure 5. Figure 5. Sely's general adaptive syndrome (Selye, 1956, p.1385). (A= typical training; B= overtraining; C= overreaching or supercompensation) (Selye, 1956, p.585)

A challenge for coaches is balancing training stress with appropriate recovery to allow continued adaptation (Halson et al., 2004). When these aspects are appropriately combined, performance capacity is enhanced. However, inappropriate training volume, intensity, and frequency combinations can result in maladaptive stress (Halson et al., 2004). Therefore, given the potential for appropriate training and match demand to maximise positive adaptations and reduce the risk of unintended outcomes, valid approaches to quantifying this process are needed (Budgett et al., 2000).

2.4 Importance of monitoring training and match demand in cricket

This section discusses the importance of monitoring training and match demand in cricket (Figure 6). Figure 6 highlights how this practice can optimise performance, prevent injuries, and contribute to cricket research. The text also emphasises the role of this monitoring in ensuring appropriate training for adolescent players.

In recent years, there has been an increase in the demand for player availability among elite-level cricketers (Christie et al., 2020). This has resulted in more demanding schedules that involve multiple training sessions (Christie et al., 2020). With the high demand for player availability, monitoring training and match demand to optimise players' performance is important (French et al., 2022). By tailoring training programs (Figure 6) to individual players and tracking volume patterns and associated performance metrics and trends over time, coaches can identify optimal training volumes, intensities, and recovery strategies for each player to maintain optimal performance levels throughout a season (French et al., 2022). This personalised approach guides decisions on player selection, rest periods, or training and match demand adjustments, maximises performance potential and ensures players are adequately prepared for matches (French et al., 2022).

In today's dynamic cricketing landscape, with players being contracted to multiple teams across the globe and the ever-increasing demands of training and match schedules, ensuring the well-being and management of players (Figure 6) has become a daunting task for cricketing institutions (Halson, 2014). The complexities of managing player fatigue and injuries while ensuring that the players perform at their best highlights the need for a comprehensive and sustainable approach towards player welfare (Halson, 2014). To mitigate these difficulties, coaches can benefit from utilising reliable, cricket-specific measures of fatigue and demand, particularly when players' access is limited (Sholto-Douglas et al., 2020). The same can be said for returning players from an injury (Figure 6) (Noakes et al., 2000). After an injury, gradually reintroducing a player and monitoring training demand during rehabilitation allows coaches and medical staff to track an injured player's progress, determine appropriate training volumes, and ensure a safe return to play (McNamara et al., 2017; Sholto-Douglas et al., 2020; French et al., 2022).

Monitoring training and match demand affects talent identification and player progression (Figure 6) (French et al., 2022). By tracking training and match demand data from junior levels to elite cricket, coaches can identify promising players, monitor their development, and make informed decisions about their progression to higher levels (Pote et al., 2016). Monitoring training and match demand helps ensure adolescent players are exposed to appropriate training and match demands and avoid excessive physical demands that could hinder their long-term development (Pote et al., 2016).

Data collected from monitoring cricket's training and match demand can contribute to cricket research and analysis (Figure 6). Collecting and analysing training and match demand data from a large sample of players enables researchers to identify training and match demand thresholds, injury patterns, and performance predictors (French et al., 2022). This knowledge can inform future training methodologies, injury prevention strategies, and player management protocols (French et al., 2022).

Adolescent cricketers are at a greater risk of injury than their adult counterparts (Stretch et al., 2014). Adolescence is a critical period of growth and development, both

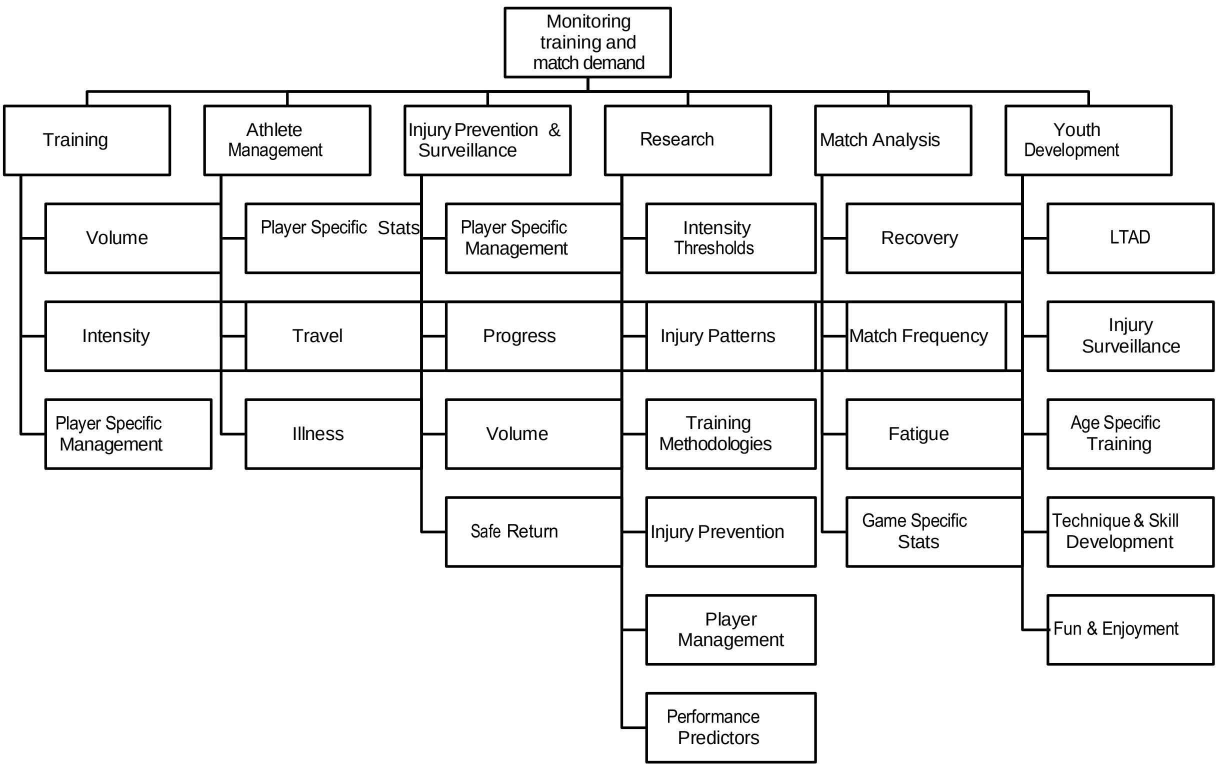

Figure 6. Aspects of monitoring training and match demand (French et al., 2022)

physically and psychologically (Stretch et al., 2014). Monitoring training and match demand helps ensure that the training and match demands placed on adolescent cricket players are appropriate for their age and stage of development (Figure 6). It helps avoid excessive training and match demand that may hinder growth or lead to overuse injuries (Caine et al., 2004). By managing training and match demand, and implementing appropriate training strategies, the risk of injury can be minimised, promoting adolescent cricket players' long-term health and well-being (Stretch et al., 2014).

Monitoring training and match demand allows coaches to ensure that young cricket players have adequate time and opportunity to develop proper technique and skill acquisition (French et al., 2022) (Figure 6). By managing training and match demand, coaches can allocate sufficient training time for skill development, repetition, and refinement (French et al., 2022). This approach fosters the development of sound biomechanics and efficient movement patterns, which are important for long-term performance and injury prevention. This will also ensure long-term growth as this is an important period for long-term athletic development in cricket (Meyers et al., 2001). This provides a balanced approach to training and competition, considering adolescent players' physical and psychological needs (Murray et al., 2018). By optimising training and match demand and progression, coaches can support the development of skills, physical attributes, and game understanding that are vital for future success in cricket (Murray et al., 2018).

During adolescence, promoting physical literacy and encouraging multisport participation is important (Figure 6) (Malina et al., 2004). Monitoring training and match demand helps ensure that cricket players have a balanced and varied sports experience, avoiding early specialisation and overemphasising cricket alone (Malina et al., 2004). By monitoring training and match demand, and managing training volumes, coaches can create opportunities for athletes to engage in other sports, promoting overall athleticism and movement diversity and reducing burn-out risk (Meyers et al., 2001).

Adolescence is a period of significant psychosocial development (Figure 6). Monitoring training and match demand helps prevent excessive physical and mental stress, which can impact the psychosocial well-being of young cricket players (Malina et al., 2004).

By carefully managing training and match demand, and ensuring appropriate recovery, coaches can support positive mental health, motivation, and enjoyment of the sport (Malina et al., 2004).

2.5 External and internal training and match demand

2.5.1 Current confusion regarding terminology

A clear and precise terminology definition is important in any field to ensure accurate communication and data representation. The exercise science domain is no different. In a recent article by Staunton et al. (2021), the authors argue that specific terms like "volume," "intensity," or "demand" are more appropriate than "load" or "work" for describing exercise constructs (Table 1). They contend that using mechanical terms like "load" or "work" can lead to ambiguity and misuse of the constructs. Furthermore, these terms may have a narrower applicability and may only be universally applicable to some situations and disciplines.

On the other hand, Impellizzeri et al. (2022) argue that the use of "load" or "work" does not necessarily go against scientific principles (Table 1). They contend that the obligation to adhere to the Système International d'Unités (SI) when describing constructs is unwarranted. The authors propose that specific words and terms should depend on current understanding and definitions. The semantic value of lexical units and terminologies is contingent upon their definitions, which must be grounded on contemporary knowledge and comprehension. They argue “that the misuse of terms occurs when a term is decontextualised or interpreted according to a unilateral perspective” (Impellizzeri et al., 2022, p. 450).

Both articles present compelling arguments, but further research is necessary to establish a clear and precise definition of terminology. Table 1 presents a summary of the terminology commonly used in cricket research, along with their definitions and how they are applied in the context of cricket. However, exact definitions for appropriate terminology will help avoid ambiguity and ensure accurate data representation. Researchers should consider the arguments presented by Staunton et al. (2021) and Impellizzeri et al. (2022). Furthermore, researchers should establish a consensus on the terminology used to describe exercise constructs, considering the latest scientific knowledge and understanding. This will help ensure that data are accurately represented, regardless of the context in which they are used.

Table 1. Key terminology used correctly and incorrectly in cricket research when monitoring and prescribing exercise

	Term	Definition
Current terms causing confusion and need clarity to be used within the research setting	Work (Work = Force x Distance)	Measured in Joule (J). Implies that mechanical work was accomplished. Incorrectly used in cricket research as no force and resistance are applied to a cricketer during a cricket-specific movement (Staunton et al., 2021).
	Load	Measured in Newton (N). Implies that resistance was encountered while carrying out the task. Confusion exists between researchers on what this term represents (Staunton et al., 2021).
Terms proposed to be used that more accurately describe monitoring and prescription of exercise	Absolute intensity	"Exercise intensity independent of an individual's physical capacity (e.g., absolute internal intensity: VO2; absolute external intensity: running speed)" (Staunton et al., 2021, p. 442).
	Adaptation	"The change process in the physical and physiological systems in response to exercise" (Staunton et al., 2021, p. 442). "With adaptation, the body will positively adapt to each acute exercise variable" (Staunton et al., 2021, p. 442). "The body negatively adapts to maladaptation due to fatigue and overtraining" (Staunton et al., 2021, p. 442).
	Exercise demand	"The product of frequency, duration and intensity" (Constable et al., 2021, p. 2). "Quantification can be done over a session, week, season, or career (Constable et al., 2021, p. 2)." It more accurately describes volume within a cricket context (Constable et al., 2021).

	Exercise intensity	“The specific level of muscular activity can be quantified regarding power (rate of energy expenditure), force, or velocity” (Winter & Fowler, 2009, p. 449). “Exercise intensity can be quantified in absolute and relative terms and measured in internal or external units (e.g., external = locomotor and mechanical; internal = physiological)” (Winter & Fowler, 2009, p. 449).
	Exercise volume	“The product of exercise intensity, time and frequency” (Pescatello et al., 2014, p. 230).
	Frequency	“The number of exercise or training sessions per day, week or month” (Pescatello et al., 2014, p. 230).
	Progression	“The advancement of the exercise program through a gradual increase in exercise volume/intensity” (Bushman, 2018, p. 7). “This is achieved by adjusting exercise duration, frequency and/or intensity until the desired exercise goal is reached” (Bushman 2018, p. 7).
	Relative intensity	“Exercise intensity specific to the individual's physical capacity (e.g., Relative Internal Intensity: % HRmax, % VO2max; relative external intensity: % maximum running speed)” (Staunton et al., 2021, p. 442).
	Time	“The duration of the exercise session or match” (Pescatello et al., 2014, p. 230).
	Type	“The mode of activity being performed, such as running, cycling or swimming” (Pescatello et al., 2014, p. 230).

2.5.2 Using the correct terms to describe exercise

Effective communication of exercise demands is important in ensuring accurate interpretation of results and implications in the field of sport science (Staunton et al., 2021). However, terminology that inaccurately describes the measured construct can lead to misinterpretation and confusion (Staunton et al., 2021). Despite the

International System of Units (SI) and numerous publications instructing researchers on proper terminology usage, terms such as "work" and "load" are often misused in research and the field of sport science (Knutgen et al., 1978; Winter et al., 2006; Winter et al., 2009; Winter et al., 2015; Knutgen et al., 2019). It is important to utilise appropriate terminology that adheres to scientific standards when describing exercise demands (Staunton et al., 2021).

Work (Force x Distance) is measured as the product of the distance (m) through which a force (N) is applied and the idea that mechanical work was accomplished (Winter et al., 2009). Joule (J) is the SI-derived unit of Work and should only be used when presenting results (Winter et al., 2009). Research that depicts "Work" in any other unit than Joules can be confusing and may lead to incorrect interpretation of the intended meaning and subsequent misunderstanding of results.

The term "load" relates to the resistance encountered while carrying out the task and should, therefore, be referred to as a Force, measured in Newtons (N) (Winter et al., 2015). Thus, the term "workload" should not be employed in exercise sciences because it can lead to confusion as it is not at all descriptive of the intended meaning and goes against both scientific standards and the SI (Winter et al., 2015).

Sports and exercise science literature often uses the term "training load" to describe exercise, but this term is not always used accurately (Staunton et al., 2021). In recent years, this term has gained popularity in describing exercise volume and intensity, but it is important to understand that it encompasses both external and internal domains (Staunton et al., 2021). External training load refers to the mechanical stress placed on an athlete during exercise, such as the distance covered between wickets or the number of deliveries bowled (French et al., 2022). In contrast, internal training load is a response to the external training load and refers to the physiological and psychological stress experienced, such as RPE and heart rate (French et al., 2022). However, there is a need for greater clarity on the definition of this term. Training load is directly proportional to the volume of exercise completed, but some authors define it as the product of volume and exercise intensity (Impellizzeri et al., 2004). Some argue that training load refers to the amount of stress placed on an individual over a period of time in response to exercise (Jaspers et al., 2017; Eckard et al., 2018).

Understanding the various definitions of "training load" is important to accurately measuring and understanding exercise volume and intensity.

From the abovementioned, it is clear that there is a need to correctly define how hard someone is training. The American College of Sports Medicine (ACSM) recommends using the acronym FITT, which stands for frequency (F), intensity (I), time (T), and type (T), to monitor and prescribe exercise. As the world's largest professional sport and exercise science professional organisation, ACSM believes the FITT principle is an efficient way to achieve fitness goals. (Pescatello et al., 2014). Recently, the concept of FITT-VP, which includes volume (V) and progression (P), has been introduced. Exercise volume is the product of intensity, time, and frequency (Pescatello et al., 2014).

The term "intensity" is an appropriate way of describing the level of exertion during exercise. This helps to avoid confusion with mechanical terms like "load" and "work" (Winter et al., 2009; Winter et al., 2015). Intensity can be applied to any situation or discipline and expressed in absolute or relative terms (Staunton et al., 2021), as shown in Figure 7. Moreover, intensity can be measured using internal or external constructs such as RPE (rating of perceived exertion), maximum heart rate (HRmax), and maximum oxygen consumption (VO2max) (Staunton et al., 2021).

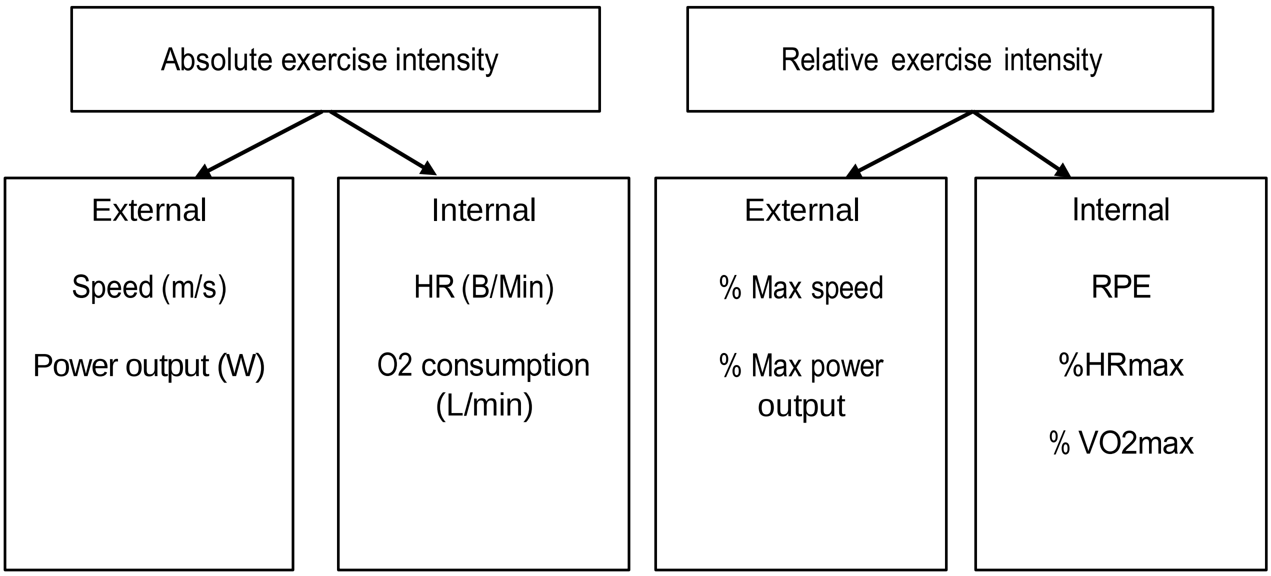

Figure 7. Internal and external outcomes commonly measure absolute and relative exercise intensity. RPE=rating of perceived exertion, HRmax=maximum heart rate, VO2max= maximum oxygen consumption

The intensity of exercise can be measured in different ways, whether internal or external. Regarding activities like running or swimming, external exercise intensity can be expressed as movement speed in the metric units of metres per second (Staunton et al., 2021). Other sports, like cycling or rowing, may use power (W), acceleration, and force (N) as measures of external exercise intensity (Staunton et al., 2021). Alternatively, intensity can be expressed relatively, such as subjective RPE or percentages of maximums (Staunton et al., 2021). These measures can help categorise exercise intensity as low, moderate, or high and can be weighted according to physiological responses such as oxygen consumption (Staunton et al., 2021).

Exercise volume is also a term that could describe how hard someone is training. “The product of exercise intensity, time and frequency” (Pescatello et al., 2014, p. 230). This term is part of the ACSM FITT-VP principle for exercise monitoring and prescription (Pescatello et al., 2014).

It is imperative to utilise accurate terminology when describing the demands of cricket to ensure clarity. In this regard, a recent study by Constable et al. (2021) evaluated the demands placed on cricket bowlers and their correlation with the likelihood of sustaining injuries. The research emphasised the significance of using appropriate terminology in describing the demand for bowling. Specifically, the 'work' (measured in joules; J) refers to the force (N) imparted on a cricket ball when bowled, multiplied by the distance over which the force is applied. In contrast, 'load' is the resistance (also expressed as N) to the work performed (Constable et al., 2021). In cricket, the two possible components of the load on the cricket ball are wind resistance and friction introduced by the ball bouncing on the pitch in transit to the batter. However, neither of these elements relates to the bowling demands experienced. Therefore, considering the demands on the body without accounting for the force and resistance experienced by the bowler does not adequately explain the training effects or injury risks (Constable et al., 2021).

The term "workload" in cricket literature is often used variably, causing confusion. For instance, studies describe bowling demand in terms of bowling frequency, duration, or intensity (Constable et al., 2021). However, none of these measurements alone can accurately determine workload, and the term "workload" needs to be used more precisely when describing bowling programs or improving injury monitoring practices.

To address this issue, Constable et al. (2021) suggested using "demand" as a more appropriate term. When combined, frequency, duration, and intensity can quantify an accumulated bowling demand over a session, week, season, or career (Constable et al., 2021).

As suggested by the researchers, the terms “intensity”, “volume”, and “demand” are more suitable to describe how hard someone is training, specifically within the context of cricket.

2.5.3 The difference between external and internal training and match demand

External and internal training and match demand are two distinct, but interrelated concepts coaches use to assess and manage the stress and demand placed on athletes (French et al., 2022).

External training and match demand refer to the objective, measurable, and quantifiable aspects of training or competition (French et al., 2022). It focuses on the physical or external factors athletes encounter during their activities. Examples of external training and match demand measures include:

- Distance - the total distance covered in running, swimming, or cycling.
- Duration - the total time spent in training or competition.
- Speed - the rate at which an athlete can move their body over a specific distance in a given amount of time.
- Repetitions - the number of times an exercise or movement is performed.
- External resistance - the amount of weight lifted or resistance applied.
- Training volume – ‘the product of exercise intensity, time and frequency’ (Pescatello et al., 2015, p. 230)

External training and match demand are typically measured using various tools and technologies, such as GPS trackers, accelerometers, heart rate monitors, and training volume cells (French et al., 2022). It provides valuable data on athletes' physical demands, allowing coaches and trainers to monitor and prescribe training effectively.

Internal training and match demand refer to the physiological and psychological responses of the athlete to the external training and match demand (French et al., 2022). It focuses on the internal or subjective factors experienced by the athlete.

Internal training and match demand are highly individualised and vary from person to person, even with the same external training and match demand (French et al., 2022). Examples of internal training and match demand measures include:

- Heart rate - the number of beats per minute, indicating cardiovascular strain.
- Perceived exertion - subjective ratings of how hard the activity feels.
- Blood lactate levels - indicative of metabolic stress and energy system usage.
- Psychological state - factors like mood, motivation, and perceived stress levels.

Internal training and match demand are assessed through athlete self-reporting, surveys, or physiological monitoring tools. It provides insights into an athlete's response to training or competition, fatigue levels, and readiness for further activity. By considering the internal training and match demand, coaches and trainers can tailor training programs, manage volume, and optimise performance while minimising the risk of overtraining or injuries.

Understanding the relationship between external and internal training and match demand is important for effective program design (French et al., 2022). By monitoring both aspects, coaches and trainers can assess the dose-response relationship, individualise training plans, and ensure athletes are adequately challenged while maintaining their overall well-being.

2.5.4 Different methods to measure external and internal training and match demand

As mentioned above, external training and match demand refer to quantifying the physical demands placed on an athlete during training sessions or competitions. It is worth noting that a combination of these methods is often used to obtain a more comprehensive understanding of the external training and match demand (French et al., 2022). Coaches and sports scientists can then analyse the data collected to optimise training programs, monitor athlete progress, and reduce the risk of overtraining or injury. Some of the most commonly used methods to measure external training and match demand are explained below.

Table 2. Methods to measure external training and match demand

Methods	**Measures**
Global Positioning System (GPS)	Tracks metrics such as distance covered, speed, acceleration, deceleration, and changes in direction.
Accelerometery or velocity-based training (VBT)	Provides information on the rate of movements, impacts, and forces.
Power meters	Measure the amount of power the athlete generates.

Global Positioning System (GPS) tracking is one of the most commonly used methods to measure external training and match demand in various sports. GPS tracks metrics such as distance covered, speed, acceleration, deceleration, and changes in direction. This method benefits continuous movement sports, like running, cycling, and team sports. Research has investigated the validity and reliability of using GPS tracking in sports. Most of these studies examined which sample rate the GPS tracking provided valid and reliable results (Johnston et al., 2010; Coutts & Duffield, 2010; Jennings et al., 2014). These studies found GPS tracking valid and reliable at specific sample rates.

Accelerometers are sensors that are capable of measuring the forces of acceleration. They can be easily integrated into wearable devices, such as GPS trackers, or attached to equipment, such as barbells or sledges, to measure the velocity or speed of movements. Athletes greatly benefit from accelerometers as they provide them with crucial information about the rate of movements, impacts, and forces that they experience during their training (Wlodarczyk et al., 2021). Velocity-based training (VBT) or accelerometery is commonly used in gym-based training as the percentage-based approach has some drawbacks (Wlodarczyk et al., 2021). The percentage-based approach assigns a specific percentage of a one-repetition maximum in a particular lift. The effectiveness of VBT is still being verified, and its scientific basis is continuously under debate, which should reassure trainers. Nonetheless, research studies conducted by Hackett (2018) and Guerriero (2018) on elite athletes have concluded that resistance training and velocity monitoring can effectively enhance sport-specific performance, endurance, and power training.

Power meters are commonly used in cycling and can measure the amount of power the athlete generates. They provide real-time feedback on the intensity of the effort and can help track training demand over time (Borresen & Lambert, 2009). The critical power concept is mainly used with power meters (Borresen & Lambert, 2009). Critical power is a concept that estimates the maximum power output that can be sustained without fatigue during a physiological steady state (Brickley et al., 2002). Identifying this marker would be helpful in determining the appropriate training regimen or evaluating the results of training interventions (Brickley et al., 2002).

As mentioned above, internal training and match demand refer to an athlete's physiological and psychological responses to training or competition. It provides insights into the overall stress and fatigue experienced by the athlete. Some of the most commonly used methods to measure internal training and match demand are explained below.

Table 3. Methods to measure internal training and match demand

Method	**Measures**
Rating of Perceived Exertion (RPE)	Subjective measure of a training session's perceived intensity or effort.
Heart rate monitoring	Popular for measuring exercise intensity.
Blood lactate transition threshold analysis	Indicates the metabolic processes of the whole body and can provide information on the metabolic stress experienced during training.
Oxygen uptake monitoring (VO2)	Steady-state exercise measurement.

The Rating of Perceived Exertion (RPE) is a method of monitoring the physiological stress experienced by athletes during exercise (Impellizzeri et al., 2004). This method involves athletes rating their perceived exertion on a numerical scale, such as the Borg RPE scale (1-10 or 6-20) or the Category Ratio (CR-10) scale (Impellizzeri et al., 2004). Athletes can adjust their training and match demand by monitoring their perception of effort. The Borg RPE scale is effective for steady-state exercise and high-intensity interval cycling (Green et al., 2006). Athletes have reported that their RPE correlates well with their average heart rate and acute changes in heart rate (Impellizzeri et al., 2004). This method provides valuable insight into the athlete's perception of the training load (Impellizzeri et al., 2004).

Heart rate monitoring, a widely accepted method for measuring exercise intensity, operates on the principle that heart rate and steady-state work rate share a linear relationship (Achten et al., 2003). While absolute intensity measures are commonly employed, the relative equivalent may yield more informative results due to the considerable differences in how individuals respond to different exercise modes (Arts & Kuipers, 1994). The percentage of maximum heart rate is often used to prescribe exercise intensity (Hopkins, 1991). However, Karvonen and Vuorimaa (1988) propose a more accurate method- using a percentage of heart rate reserve. This method, which considers the variations in resting heart rate with age and fitness level and the decrease in maximal heart rate with age, provides a more accurate quantification and prescription of intensity, instilling confidence in its application.

Heart rate monitors are commonly used to measure heart rate during exercise. However, the relationship between workload and heart rate can be influenced by several factors. The day-to-day variation in heart rate is about six beats per minute (Lambert et al., 1998) or less than 6.5% (Bagger et al., 2003). Heart rate accuracy can improve if factors such as training, environmental conditions, exercise duration, hydration status, altitude, and medication are controlled (Achten et al., 2003).

Blood lactate transition analysis is viewed as an exerkine and indicates the metabolic process of the whole body, which can provide information on the metabolic stress experienced during training (Borresen & Lambert, 2009). By measuring lactate levels before, during, and after training sessions, coaches can assess the intensity and metabolic demands placed on the athlete (Borresen & Lambert, 2009). Measuring blood lactate levels has become easier with portable instruments and a single-finger prick (Borresen & Lambert, 2009). However, it still needs to be practical to measure lactate frequently for intensity (Borresen & Lambert, 2009). The lactate threshold measures endurance fitness and helps standardise training (Pyne et al., 2001). During endurance events, an exercise intensity producing a lactate concentration of 4 mmol/L is optimal for inducing physiological adaptations (Weltman et al., 1992).

During steady-state exercise, the relationship between oxygen consumption and the work rate is linear (Robinson et al., 1991). This is measured through oxygen uptake monitoring (VO2). However, VO2 is not valid for interval or supramaximal exercise bouts. Exercising below the lactate threshold exponentially increases VO2 to a steady-state level. However, when exercising above the lactate threshold, VO2 becomes more complicated (Xu & Rhodes, 1999). Comparing athletes' exercise intensities of different physiological and performance characteristics, relative (%VO2max) values of VO2 have been used (Hopkins et al., 1991). Before prescribing or quantifying exercise using relative VO2 values, the mode must be determined as VO2 max is mode-specific (Hopkins et al., 1991). Moreover, VO2 kinetics at the onset of exercise may differ with the level of physical training, age, and disease, making it inappropriate to prescribe relative exercise intensity using VO2 (Hopkins et al., 1991).

Combining internal training and match demand measures with external training and match demand measures provides a more comprehensive understanding of an athlete's overall training stress, helping coaches make informed decisions about training volume, intensity, and recovery strategies.

Assessing the need for internal and external training and match demand can present challenges in adolescent cricket. Although various methods exist for measuring training and match demand, many are costly, like GPS, force plate measuring systems, and heart rate monitors. Others may require better reliability and validity, such as non-standardised questionnaires. While some of these approaches may not be feasible in an adolescent setting, some can prove helpful in measuring training and match demand for young athletes (Borresen & Lambert, 2009). The available tools must address cricket and the demands placed on adolescent cricketers and be within the context of adolescent cricket in South Africa.

2.6 The Acute:Chronic workload ratio (ACWR)

2.6.1 The use of Acute:Chronic workload ratio (ACWR)

Most of the measurements mentioned above are implemented in professional cricket (both national and provincial levels) and provide comprehensive information about the player’s readiness to compete, as seen in the research done by Petersen (2009), where they showed that the use of GPS monitoring in cricket is both a valid and reliable method to measure training and match demand in cricket. However, using these technologies in school sports is only sometimes feasible. GPS and heart rate monitors for teams can be expensive, and implementing these systems is only occasionally possible across all the sporting codes as most school cricket players compete in various sports within a season. Therefore, there is a need to find an effective method that is inexpensive and easy to implement across all sporting codes, which will still provide valid and reliable data on the overall training demand.

Acute demand refers to the recent or short-term training and match demand experienced by an athlete (French et al., 2022). It typically covers a period of a few days or up to a week. Acute training and match demand measure the current demands on an athlete's body, capturing the intensity, duration, and volume of training or competition during that period (French et al., 2022).

Chronic demand represents the longer-term or accumulated training and match demand over a more extended period, typically four weeks (French et al., 2022). It reflects an athlete's baseline or habitual training level and represents their overall conditioning and preparedness (French et al., 2022).

Monitoring the ACWR is based on the assumption that a rapid increase or spike in acute training and match demand, relative to the chronic training and match demand, can increase the risk of injury (Hulin et al., 2014; Bourdon et al., 2017; Griffen et al., 2019). When the ratio is too high, it suggests a rapid and significant increase in training and match demand for which the athlete may not be adequately prepared (Hulin et al., 2014; Bourdon et al., 2017; Griffen et al., 2019). The sudden change in demand could lead to chronic fatigue, inadequate recovery, and a heightened risk of overuse injuries (Hulin et al., 2014; Bourdon et al., 2017; Griffen et al., 2019). Training below the ratio could lead to undertraining and injuries as the player is underprepared for sudden spikes in the training and match demand (Hulin et al., 2014; Bourdon et al., 2017; Griffen et al., 2019).

The ACWR is calculated by dividing the acute training and match demand by the chronic training and match demand. For example, if an athlete's acute training and match demand for the week is 500 units and their chronic training and match demand average over the past four weeks is 400 units, the Acute:Chronic workload would be 500/400, which equals 1.25. The optimal range for the Acute:Chronic workload is context-specific and can vary depending on the sport, athlete, and individual factors (French et al., 2022). Research suggests that maintaining the ACWR within a range of 0.8 to 1.3 (Figure 8) is generally associated with reduced injury risk and improved performance outcomes (Hulin et al., 2015; Bourdon et al., 2017; McNamara et al., 2017; Griffen et al., 2019).

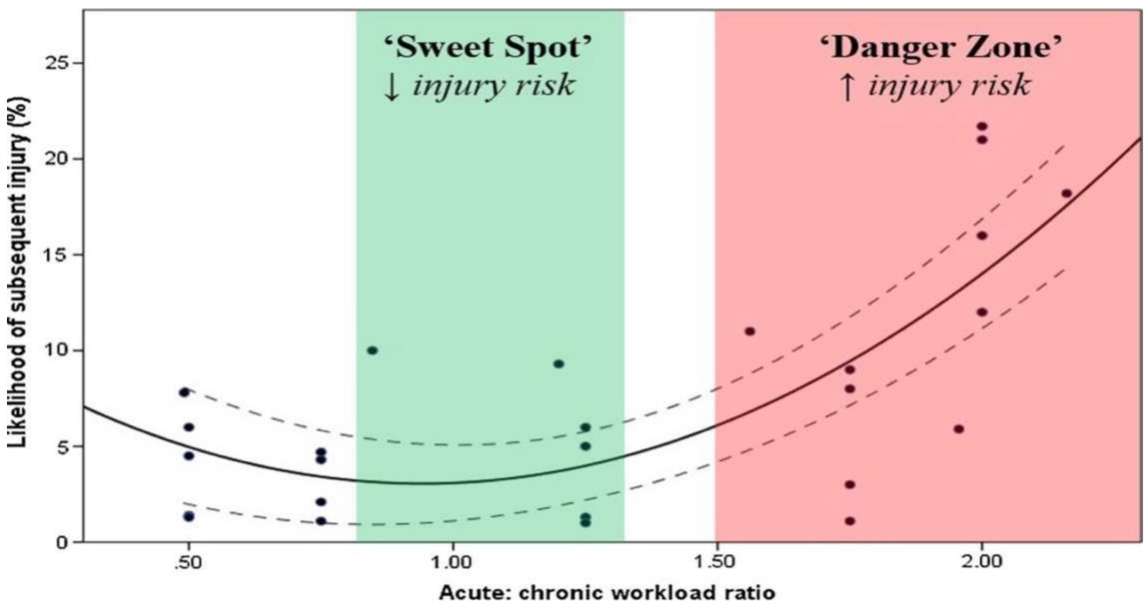

Figure 8. Acute:Chronic Workload Ration Chart

"Figure 8 is based on studies from three sports, a relationship was established between the ACWR and injury risk" (Figure 7) (Bourdon et al., 2017, p. 162). "The green-shaded area covers ACWR within a range of approximately 0.8–1.3, representing a 'sweet spot' where injury risk is low" (Figure 8) (Bourdon et al., 2017, p. 162). "The red-shaded area covers ACWR of 1.5 and above, representing a 'danger zone' where injury risk is high" (Figure 8) (Bourdon et al., 2017, p. 162).

Coaches and sports scientists can use the ACWR to guide load management strategies (Hulin et al., 2014; Bourdon et al., 2017; Griffen et al., 2019). By monitoring the ratio, they can identify periods of rapid training and match demand increases, plan appropriate training progressions, and implement recovery strategies to ensure a gradual and appropriate adaptation to training demands. Adjusting training and match demand based on the ACWR helps reduce the likelihood of sudden spikes in load that may lead to injury (Hulin et al., 2014; Bourdon et al., 2017; Griffen et al., 2019).

It is important to consider individual athlete characteristics when interpreting the ACWR (French et al., 2022). Factors such as an athlete's injury history, training history, age, and overall physical condition should be considered (French et al., 2022). Different athletes may have different optimal ranges and responses to workload changes, and their thresholds need to be considered when managing load (French et al., 2022).

Training and match demand questionnaires can be used to determine ACWR to measure training and match demand and that spikes in these training and match demand can lead to injuries (Griffin et al., 2019). Griffin et al. (2019, p. 568) looked at "the association between ACWR and injury and its application in team sports" in their review, which aimed to examine the correlation between injury occurrences and the ACWR and provide recommendations on how to apply the method in team sports. The review of the studies included in the analysis showed that there is indeed evidence for a relationship between ACWR and injuries. Nearly all studies, except for one, found a significant connection between ACWR and injury (Griffin et al., 2019). These studies were published in 2018, and the ACWR method for monitoring training and match demands is gaining interest (Griffin et al., 2019). The author concluded that more clarity regarding injury reporting and the most appropriate method for calculating ACWR is needed.

Care should, however, be taken when using ACWR to determine the training and match demand, as it is important to understand the distinctions between multiplicative (ratio) and linear scales when analysing data (Impellizzer et al., 2021). Some experts caution against using ratios and percentages because their values depend on the direction of the comparison (Impellizzer et al., 2021). For example, reducing the training load from 1000 to 800 meters results in a 20% relative decrease, but increasing it from 800 to 1000 meters results in a 25% relative increase (Impellizzer et al., 2021). These multiplicative changes differ from additive ones, which are linear (Impellizzer et al., 2021).

Additionally, ACWRs are proportions that rely on the denominator, making them sensitive to individual players' absolute acute demand (Impellizzer et al., 2021). This can lead to model miscalibration, as players with low acute demand may have higher ACWRs. For instance, injured players with the lowest acute demand values may be placed in the higher category of the ACWR (Impellizzer et al., 2021).

However, the use of ACWR has also been well-researched in cricket. Hulin et al. (2014) researched the use of ACWR by measuring the training and match demand in elite cricket fast bowlers. The aim was to determine if spikes in acute training and match demand could lead to injuries (Hulin et al., 2014). The findings of this study demonstrate that significant increases in acute training and match demand are associated with increased injury risk in elite cricket fast bowlers.

2.1.1 Models used to calculate the Acute:Chronic workload ratio

There is much debate among researchers as to what the best model to determine the ACWR is (Wang et al., 2020). Most discussion is around the sensitivity to change in these models or that some models are less accurate, providing a precise ratio that genuinely represents the actual training and match demand (Wang et al., 2020). Various models could determine the ACWR with varying sensitivity levels (French et al., 2022).

Table 4. Models used to calculate the ACWR

Models	Definition
Exponential weighted moving average (EWMA) model (Roberts, 1959)	Uses a weighted average of the training and match demand to give more weight to the more recent training sessions while still considering the past training sessions
Rolling average model (RA) (Drew et al., 2016)	Uses the average of the acute and chronic training and match demand over a rolling period
Triangular model (Gordon, 1988)	Uses the sum of the acute training and match demand over the previous seven days and dividing it by the sum of the chronic training and match demand over the last 28 days
Exponentially weighted moving median (EWMM) model (Wold, 1994)	Uses the median rather than the mean to calculate the acute and chronic training intensity

Z-Score model (Altman et al., 1977)	Compares the current training and match demand to the historical average training and match demand and standard deviation.
Bayesian model (Merlise, 1999)	Estimates the probability of injury based on the athlete's training and match demand history

The Exponential weighted moving average (EWMA) model is a commonly used approach to calculate acute and chronic workload ratios in sports science. The model uses a weighted average of the training and match demand to give more weight to the more recent training sessions while still considering the past training sessions (French et al., 2022).

The EWMA and RA models are the most commonly used for determining the ACWR. Research done by Griffen et al. (2019) reviewed the association between the ACWR and injury. According to the review, the EWMA method proves to be more sensitive and effective than the RA model in determining the ratio. In calculating ACWR, the RA model simplistically considers a linear association between training and match demand and injury, treating each acute period within the aggregated chronic period equally. However, it is important to be aware that, despite these limitations, a substantial amount of literature is endorsing its use.

In their 2014 study, Hulin et al. found that a ratio of 7:28 in the ACWR in cricket players was associated with an increased risk of injury. Hulin et al. (2014) found that acute and chronic training and match demands were not consistently linked to injury. However, there was a significant association when combined to form the ACWR. However, Griffen et al. (2019) found that a more rigorous model, represented by the EWMA, was required.

An editorial published in the British Journal of Sports Medicine (BJSM) by Menaspa in 2016 raised concerns regarding the use of rolling averages for assessing workload. The editorial argues that rolling averages do not consider the time frame in which a stimulus occurred, nor do they account for the decaying nature of fitness and fatigue effects over time, as suggested by Hawley (2002) and Menaspa (2016), respectively. While there is a hypothesis that a non-linear training load model might be more effective in quantifying injury risk, the ACWR model, backed by evidence (Gabett, 2016; Drew et al., 2016), remains the best approach for modelling the relationship between demand and injury in various sports (Drew et al., 2016). However, it is crucial to acknowledge that there is currently no evidence supporting the superiority of a non-linear training load model over the ACWR model, indicating a need for further research in this area.

The Exponentially Weighted Moving Average (EWMA) was introduced by Williams et al. (2017) to calculate the ACWR to overcome the issues highlighted by Menaspa (2016). The Rolling Average (RA) method must consider the diminishing effects of fitness and fatigue over time and the non-linear relationship between injury occurrence and training intensity. Subsequently, further research has been conducted to explore the EMWA approach, with each study providing robust evidence in favour of its application (Murray et al., 2016). Murray et al. (2016) confirm that both ACWR models are linked to a higher risk of injury. However, they suggest that the EWMA model is more sensitive and, therefore, more suitable than the traditional RA model. The RA model might underestimate the risk of injury at higher ACWRs.

2.2 Monitoring training and match demand in adolescent cricket

Monitoring cricket's training and match demand is a relatively new concept, and few published articles are available on elite cricketers (Christie et al., 2020). Most of the available literature focuses on elite fast bowlers, as demonstrated by the studies of Christie et al. (2020); Constable et al. (2022) and Christie et al. (2023). However, there is a need for more research that links training and match demand to performance (Christie et al., 2023). Some studies have explored how repeated bowling spells can impact bowling performance (McNamara et al., 2016), while others have investigated muscular damage following acute bouts of bowling (Christie et al., 2023). Combining training and match demand with other measures in elite cricketers can help identify various physical and physiological variables (McNamara et al., 2016).

Elite fast bowlers have been found to have a higher match demand compared to non-fast bowlers. As a result, they tend to experience a more significant fatigue response (McNamara et al., 2016). It is recommended that elite bowlers bowl between 123 and 188 deliveries per week (McNamara et al., 2016). Bowling below or above this range has been linked to an increased risk of injury (Dennis et al., 2005). More than three and a half days between sessions and bowling more than fifty deliveries per day can also increase the risk of injury (McNamara et al., 2016). Additionally, it has been suggested that bowling less than two or more than two and a half days per week could also lead to injury (McNamara et al., 2016). These studies highlight the need for more research on monitoring fast bowler training and match demand (Dennis et al., 2005; McNamara et al., 2016).

Evidence suggests that a high acute training demand in fast bowlers can increase the risk of injury that may occur up to 21-28 days after the acute overload has occurred (Saw et al., 2010; Hulin et al., 2014; McNamara et al., 2016;). Several studies have linked this "acute overload" or spikes in training and match demand to increased injury risk (Saw et al., 2010; Hulin et al., 2014; McNamara et al., 2016). ACWR is often used to visualise this overload. A study by Orchard (2015) found no increased risk of injury 28 days after the higher match bowling demand for 12 to 26 days. However, the injury rates were higher if the bowling demand exceeded 100 overs in 17 days or less. According to Orchard et al. (2015), elite fast bowlers have a 3-4 week delayed injury risk following spikes in acute workload. However, Hulin et al. (2014) found that the injury risk increased significantly one week after such spikes.

There needs to be more evidence of the demands of different playing positions in cricket (Saw et al., 2010). However, studies have shown that elite cricketers with a higher throwing demand are at a greater risk of injury (Saw et al., 2010). In a study conducted by Saw et al. (2010), it was found that injured players had thrown more than 75 times per week with fewer rest days in the week leading up to the injury. Therefore, an increased demand for throwing can increase the risk of upper limb injuries in cricketers (Saw et al., 2010). Saw et al. (2010) also noted that more research should be conducted to analyse the throwing demands of specific cricket disciplines in conjunction with their combined training and match demands. All cricket players must bat and field, while others must bowl and keep wicket.

A study by Orchard et al. (2015) found that high bowling demand was linked to various injuries. Fast-bowling training can increase the risk of tendon, muscle, bone, and joint injuries (Orchard et al., 2015). High acute match and previous season demand are risk factors for tendon injuries. On the other hand, a high previous season demand protects against muscle injuries (Orchard et al., 2015). It is suggested that training and match demand planning should be personalised, as some players are more susceptible to specific injuries than others (Orchard et al., 2015).

The studies above have mainly focused on only fast bowlers and elite players within Australia. Very few studies have been published to date that looked at the training and match demand placed on adolescent cricketers (Pote & Christie, 2019; Christie et al., 2020). A pilot study by Pote and Christie (2019) examined training and match demand placed on adolescent cricketers. No relationship between training and match demand and injuries was found; however, this could be due to the small sample group. However, the methods used in the study were practical and could be used on a larger group. The RA model was used to determine the ACWR, and as mentioned in a previous section above, this could also lead to a misrepresentation of the actual ACWR. Thus, more research needs to be done on adolescent cricket players because they are at a greater risk of injury than their adult counterparts. Furthermore, no studies have focused on the high training and match demand placed on adolescent batters or the injury risk of high throwing demands.

Chapter 3 Study 1 - Validity and reliability study

3.1 Study Design

This study is a quantitative validity and reliability study.

3.2 Participants

3.2.1 Source of Participants

A sample of convenience was used. Permission was obtained from the Gauteng Department of Education (Appendix B) and a high school's governing body to directly approach the players and coaches of the high school's 1st and 2nd cricket team before and after practice in order to invite them to participate in the research study. Players and coaches were approached between July and August 2022, before the third term cricket season started. Researchers with a research background in cricket, who obtained master's and doctoral degrees from the University of the Witwatersrand and are currently working in the field of cricket as physiotherapists and sports scientists, were also invited to participate in the study.

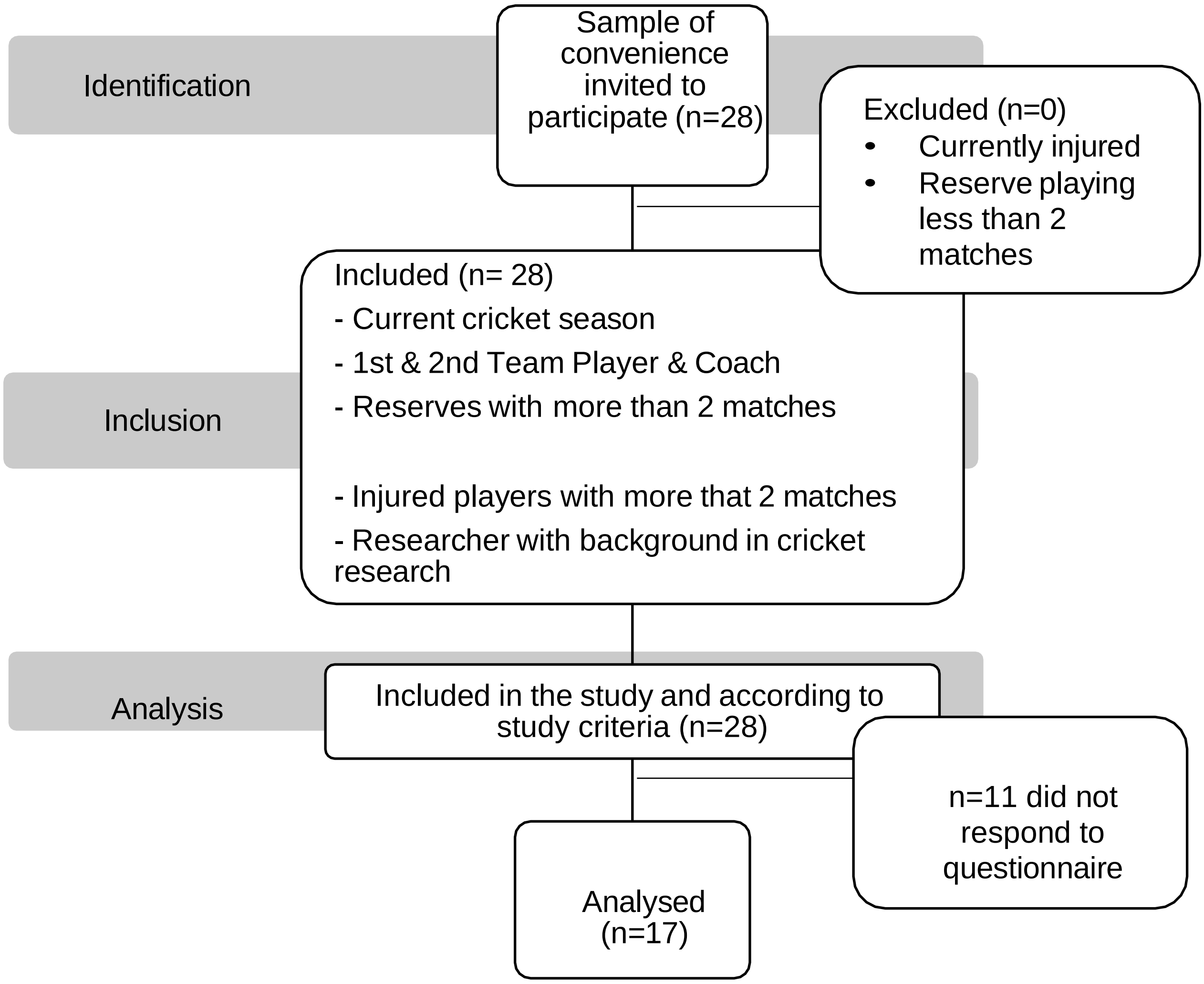

Figure 9. Observational study flow diagram for Study 1

3.2.2 Sample Size

A sample of convenience of adolescent cricket players from a single high school was used. A sample proportion was used in lieu of a mean due to the sample size. A total of 28 participants were invited to participate; of the 28 participants, 17 responded. The participants consisted of adolescent cricketers from the high school's 1st and 2nd teams, as well as the coaching staff of the respected teams. Reserves that entered any of the respective teams due to an injury to any of the invited participants and met the inclusion criteria could also be included. Three researchers from the University of the Witwatersrand were invited to participate. The three researchers were chosen because of their experience with validating tools for cricket.

3.2.3 Sample Selection

3.2.3.1 Inclusion Criteria

The following inclusion criteria were used for the study:

- Adolescent cricketers between the ages of 16 and 18 participating in the current cricket season for the high school's 1^{st} and 2^{nd} cricket teams.
- Coaching staff members of the 1^{st} and 2^{nd} teams.

3.2.3.2 Exclusion Criteria

The following exclusion criteria were used for the study and specifically pertains to the test-retest component of the study:

- Players currently injured and not able to participate in the cricket season.
- Hours and matches of reserves and injured players who had less than two consecutive weeks of training and matches for either 1^{st} or 2^{nd} team during the current season.

3.3 Training and match demand questionnaire

The newly designed questionnaire (Appendix A1, original questionnaire) was formulated from studies that used similar measurements to measure training and match demand in cricket and other sport (Hulin et al., 2014; Murray et al., 2018; Murray et al., 2017; Pote & Christie, 2019; Christie et al., 2020; Constable et al., 2021; Staunton et al., 2021). The newly designed questionnaire encompasses the correct terminology to accurately describe how hard someone is training in the context of cricket; specifically, the terms "load", "player load", and "workload" were replaced by more appropriate terms, including “training intensity” and “demand”. The term “intensity” describes how strenuous or challenging an individual exercise or workout is. This helps gauge the effort required for that specific activity. On the other hand, the term “demand” was used to describe the overall physiological requirements and energy expenditure associated with a workout or an exercise routine (see sections 2.5.1 and 2.5.2 in the Literature Review for more information). Previous questionnaires only focussed on bowling-specific demands and did not include the demands from batting, fielding or any other activity that could impact the athlete's overall training demand. The newly designed questionnaire includes information that will allow for the calculation of ACWR.

The questionnaire enquires about session duration, rating of perceived exertion (RPE) and session RPE (sRPE). Rating of perceived exertion is a subjective way for individuals to subjectively assess and communicate how hard they perceive an exercise or workout to be (Impellizzeri et al., 2004). ~~The sRPE method considers the intensity and the duration of the training session (or competition) to calculate the training and match demand (Duration X RPE = sRPE) (Haddad et al., 2014).~~ Session RPE and RPE are related concepts used to assess perceived exertion during exercise. However, they are used in slightly different contexts and for different purposes (Haddad et al., 2014). Rating of perceived exertion assesses perceived exertion for specific segments or phases of exercise, allowing individuals to adjust their effort level in real-time during a workout (Haddad et al., 2014). Whereas sRPE assesses the overall perceived exertion for an entire training session or workout, providing a cumulative measure that helps coaches and athletes monitor training and match demand and adjust training plans over time (Haddad et al., 2014). Session RPE offers a broader perspective on how challenging the entire session felt to the individual (Haddad et al., 2014).

The sRPE-based training demand was defined as the sRPE multiplied by the session's duration in minutes. The ACWR was calculated by using the exponentially weighted moving and rolling average models. These ratios were determined for all the various aspects of cricket, such as bowling, batting, fielding, and strength and conditioning sessions. The various aspects were determined independently, and then a combined measurement was determined. The ratios were also determined for all other sports the participants participated in by determining the ACWRs.

Specifically concerning bowling, batting, and fielding, the questionnaire measured the number of deliveries bowled, the number of balls faced in a batting session, and the total number of balls thrown in a fielding session. These values are important as there are specific norms on how many deliveries individuals are allowed to bowl per training session; also, if a certain number of balls thrown or faced during battling could related to injuries, as there are no specific norms on the number allowed.

3.4 Procedure

The study involved eligible players, reserve players and coaching staff members of a high school's 1st and 2nd cricket teams. It also involved researchers with a background in cricket research from the University of the Witwatersrand.

Players assessed the test-retest reliability twice one week apart, while researchers and coaches evaluated the content validity. The evaluation focused on the terminology used in the questionnaire, ensuring that it was cricket-specific and understandable for adolescent cricketers to complete accurately.

Study data were collected and managed using REDCap (Research Electronic Data Capture) electronic data capture tools hosted at The University of the Witwatersrand (Harris et al., 2009; Harris et al., 2019). All responses were anonymous to ensure that the feedback received was accurate and truthful. The finalised questionnaire (Appendix A2) was used in the Study 2.

3.4.1 Content Validity

Coaches and researchers were asked questions about the questionnaire's content. They were required to rate these questions from 1-5 (five being most relevant and one least relevant. The content validity index (CVI) was used to measure the questionnaire's content validity. The two most commonly used methods to calculate the CVI are item-level CVI (I-CVI) and scale-level CVI (S-CVI) (Polit & Tatano, 2016). The I-CVI assesses the content validity of individual items, while the S-CVI evaluates the overall content validity of the entire scale or instrument (Polit & Tatano, 2016).

The I-CVI is calculated by dividing the number of experts rated an item as content-valid by the total number of experts (Yusoff, 2019). A commonly used criterion for agreement is a minimum I-CVI of 0.78, which means that at least 78% of the experts agree that an item is content-valid (Yusoff, 2019). The S-CVI is calculated by averaging the I-CVI values across all items in the scale (Yusoff, 2019). A commonly used criterion for acceptable S-CVI is 0.80 or higher, indicating that at least 80% of the items are considered content-valid by the panel of experts (Yusoff, 2019). The S-

CVI score was used with other factors, such as expert feedback, previous research, and established standards, to make informed decisions about content validity.

Both the I-CVI and S-CVI provide valuable information about the content validity of an instrument, helping researchers determine whether the items adequately represent the construct of interest. By ensuring content validity, researchers can have greater confidence in the accuracy and relevance of their measurement instrument's results (Polit & Tatano, 2016).

3.4.2 Test-retest reliability

Test-retest reliability was measured to determine if the questionnaire provided stable and consistent results, ensuring repeatability. Kendall's coefficient of concordance (Kendall's W) was used to measure the test-retest reliability. The measurement accounts for the strength of the relationship between multiple ratings (Lange, 2011). It measures the extent of agreement rather than only absolute agreement. Kendall's coefficient ranges from 0 to 1 (Table 5). W = 0 indicates no agreement or complete disagreement among the raters, and W = 1 indicates perfect agreement or complete concordance (Lange, 2011). Table 5 describes the degrees of agreement when using Kendall’s W.

Table 5. Kendall's W concordance degree scale

Kendall's W	Interpretation
0	No agreement
0.10	Weak agreement
0.30	Moderate agreement
0.60	Strong agreement
1	Perfect agreement

3.5 Ethical Considerations

Ethical clearance was applied for from the University of the Witwatersrand Human Research Ethics Committee (Appendix H). Permission to access participants was obtained from the high school and the Gauteng Department of Education (Appendix B). Informed consent was obtained from the parents of minors, and assent was additionally obtained from the minors themselves (minors = under the age of 18 years) (Appendix C). Participants were informed that they could withdraw from the study at any time without suffering any repercussions. Informed assent was requested annually prior to commencing data collection.

All record keeping and information were treated and handled in compliance with the Protection of Personal Information Act (POPIA). Only the information officer and assigned assistant had access to the information. The information from this study was used solely for its intended purpose. The name of the high school has been redacted to respect the privacy of the school, its staff, and its students.

3.6 Results Study 1 – Validity and reliability study

The following section presents the results from the content validity test using the content validity index and the results of the test-retest reliability test using Kendall's coefficient.

3.6.1 Content used

The questionnaire (Appendix A1) utilised in the study underwent revisions based on feedback from cricket coaches. The alterations focused on the language and methods used in the cricket community. Specifically, coaches recommended a shift from tracking the number of deliveries bowled to counting overs bowled, which is the standard method used in the sport. Additionally, session types were labelled with cricket-specific terms such as nets, middle practice, and match. These revisions were made to enhance the alignment of the questionnaire with the practices and terminology utilised in the cricket coaching community.

3.6.2 Content validity

Most I-CVI scores for the questions asked rating the questionnaire are above the minimum accepted value of 0.78 (Tables 6 and 7). The S-CVI of 0.95 is above the ideal value of 0.80. The S-CVI can, in some instances, be influenced by the low number of experts rating the questionnaire, i.e., 6. However, the low number did not influence the S-CVI. The S-CVI score was used with other factors, such as expert feedback, previous research, and established standards, to make informed decisions about content validity, compensating for the limited number of participants. The average I-CVI score is above the minimum accepted value of 0.78, which means that at least 78% of the experts agree that the content is valid (Table 6). Thus, the questionnaire can be deemed as valid.

Table 6. Results from content validity index, I-CVI and S-CVI scores

Item Description (Rating scale range from 1-5)	**Coach / Researcher rating (1-5)**						**Level of agreement**	**I-CVI**	**UA**
	1	**2**	**3**	**4**	**5**	**6**			
Is the content relevant to adolescent cricket?	5	5	5	5	5	4	6	1	1
Will the content provide valuable data to you as you coach?	5	5	5	5	4	5	6	1	1
Will adolescent cricketers be able to complete the questionnaire?	4	4	4	4	4	4	5	0.83	0
Are the terms in the questionnaire easy to understand?	5	5	5	5	4	4	6	1	1
							S-CVI/Avg		0.95
							Total agreement		3
							S-CVI/UA		0.75

The scores for content validity, evaluated by six different raters, are presented in Table 7. Each rater assessed every item, and the majority of them were scored a four or five. However, it is worth mentioning that the item "Will adolescent cricketers be able to complete the questionnaire?" did not receive a perfect score of five from any of the raters. Instead, all raters assigned it a score of four.

Table 7. Descriptive statistics for all content validity scores

	n	Mean	Std. Deviation	Minimum	Maximum
Is the content relevant to adolescent cricket?	6	4.83	.408	4	5
Will the content provide valuable data to you as coach / researcher?	6	4.83	.408	4	5
Will adolescent cricketers be able to complete the questionnaire?	6	4.00	.000	4	4
Is the terms used to describe the questionnaires easy to understand?	6	4.83	.408	4	5

3.6.3 Test-retest reliability

Kendall's coefficient ranges from 0 to 1, where higher values indicate stronger test-retest reliability (Table 5). Values greater than 0.9 are excellent, and 1 indicates perfect agreement. The Kendall's coefficient for the questionnaire scored 0.63 (Table 8). This indicates a strong positive test-retest reliability (Table 5).

Table 8. Kendall’s Coefficient of variance

Test statistics	
n	6
Kendall’s W	0.632
Chi-squared	11.372
df	3
Asymp. Sig.	.010

3.7 Discussion

During Study 1, participants were asked to evaluate and complete a questionnaire (Appendix A1) that monitored the match and training demand of the participants. The study's results deemed the questionnaire a valid and reliable tool to measure training and match demand in adolescent cricketers. The questionnaire developed in Study 1 provides coaches and sports coordinators with a means to effectively monitor adolescent cricketers' training and match demands.

The content validity of a questionnaire is crucial to ensure that it accurately measures the intended content or construct. The I-CVI scores should exceed 0.78, and a good content validity score enhances research data's accuracy, validity, and credibility. Most of the questions scored 1.0, with one scoring 0.83, falling above 0.78, the minimum accepted value. The S-CVI of 0.95 falls above the commonly accepted criterion of 0.80, indicating that the questionnaire is valid (Table 6).

The Kendall’s coefficient for the questionnaire scored 0.63 (Table 8). This indicates a strong and positive test-retest reliability (Table 5). The low number of adolescent cricketers evaluating the reliability of the questionnaire influenced Kendall’s W value, which can affect the level of agreement, thus influencing the test-retest reliability. This was mainly due to a compliance problem from the adolescent cricketers. This is also a common questionnaire problem in other research studies (Pote & Christie, 2019). Future research should look at how to solve this problem, especially in an adolescent setting.

The I-CVI, S-CVI, and Kendall’s W scores were used in conjunction with expert feedback, previous research, and established standards, to make informed decisions about the validity and reliability of the questionnaire. From this, it was concluded that the questionnaire is both valid and reliable for measuring training and match demand in adolescent cricketers.

Based on suggestions from cricket coaches, the questionnaire's wording was revised, with changes made to the bowling section. Originally, adolescent players were asked to keep track of the number of deliveries bowled, but coaches recommended switching to counting overs bowled, as this was their typical method for tracking deliveries per session. Additionally, the revision included labelling session types with cricket-specific terms like nets, middle practice, and match.

Coaches and sports coordinators play a crucial role in monitoring adolescent cricket players' training and match demands. To ensure that these adolescent athletes remain healthy and injury-free, it is essential to have a valid and reliable questionnaire to track their progress and identify any potential issues.

By understanding the demands placed on these adolescent players, coaches and coordinators can take early action to prevent injuries and burnout. This may involve adjusting training programs, modifying schedules to avoid monotony, and accounting for other school commitments. These adjustments can help ensure that adolescent cricketers receive the support they need to excel in their sport while maintaining their overall well-being.

Moreover, utilising a questionnaire can assist coaches and coordinators in embracing the individuality of adolescent cricketers who require additional attention. It can help them identify players experiencing life stressors, such as academic or personal challenges, and provide them with the necessary support to overcome these obstacles.

Overall, having a valid and reliable questionnaire is essential for coaches and sports coordinators to monitor adolescent cricket players' training and match demands effectively. It can help ensure these young athletes receive the support they need to thrive on and off the field.

Extensive research has been conducted on different methods to measure external and internal demand. However, budget constraints often prevent their implementation. For instance, the cost of a comprehensive GPS system to monitor an adolescent cricket team can range from R300,000 to R1,000,000 per year, making applying to an adolescent cricket team impractical. In addition, most adolescent cricketers compete in more than one sport, making interpreting GPS data difficult. Some sports are only sometimes done at school, which makes the logistics of using GPS systems challenging. Therefore, finding cost-effective ways to measure all sports' training and match demand is important.

The developed questionnaire can be easily adapted and validated in other sports to monitor their demands accurately, making it a reliable tool for monitoring adolescent demands across various sports. This adaptability is primarily achieved through the modification of the questionnaire's wording to reflect the unique demands of each sport accurately. For example, hockey players will need to be asked about meters ran within a session while rugby players will need to be asked about meters ran, tackles made and a specific focus on session type (defence session, position specific sessions, etc.) It is worth noting, however, that the method used to measure ACWR remains unchanged, as it is universally applicable and has been proven effective in monitoring adolescent training and match demand.

By using a consistent process to measure ACWR in adolescents across multiple sports, it will be possible to generate a long-term dataset. This dataset will allow for the monitoring of adolescent cricketers' training and match demands over an extended period, enabling coaches and trainers to prevent over or under-training. This, in turn, can help to prevent injuries, burnout, and suboptimal performance. The availability of this data will enable coaches and trainers to make informed decisions regarding their athletes' training regimes, ultimately contributing to their overall physical and mental well-being.

Chapter 4 Study 2 - Training and match demand in adolescent cricketers over 7 weeks: a Pilot Study

4.1 Study Design

This pilot study is a descriptive longitudinal cohort study and was conducted and analysed as a balanced panel design.

4.2 Participants

4.2.1 Source of Participants

A sample of convenience was used. The sample consisted of cricketers from a high school's U/15 A & B, U16 A & B, and 2nd and 1st cricket teams.

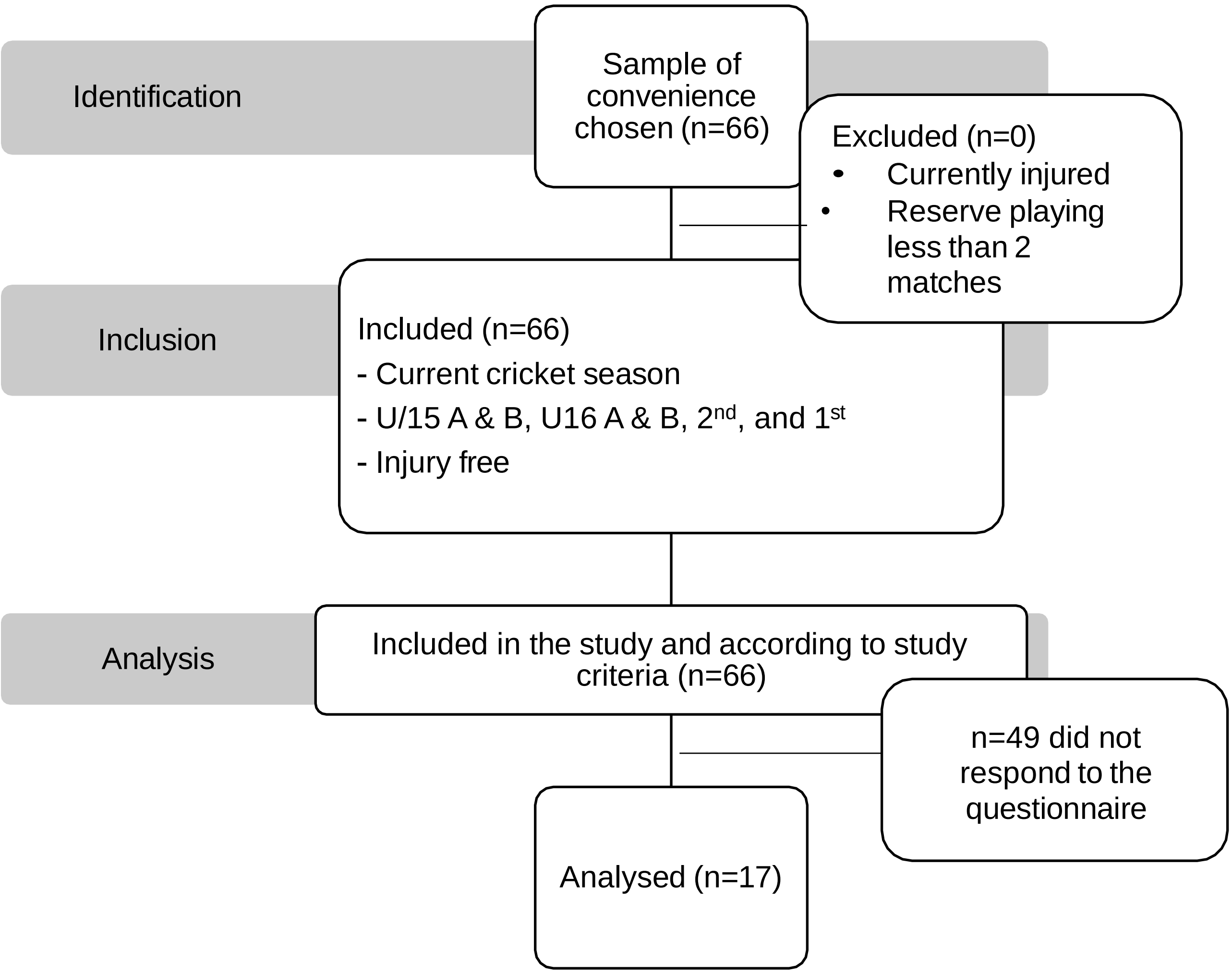

Figure 10. Observational study flow diagram for Study 2

4.2.2 Sample Size

All adolescent cricketers of a high school's U/15 A & B, U16 A & B, 2nd, and 1st cricketing teams who met the inclusion criteria (n=66) were invited to participate. Of the 66 eligible participants, 19 responded, while 17 completed the questionnaires. Follow-up invitations were sent out once to the other 49 participants, with no response. No further follow-up invitations were sent out to avoid coercion.

4.2.3 Sample Selection

4.2.3.1 Inclusion Criteria

- Participants from a cricket-playing high school's U/15 A & B, U16 A & B, 2nd, and 1st cricket teams were fit for selection and injury-free at the time of the study.

4.2.3.2 Exclusion Criteria

- Currently injured and not able to participate in the current cricket season.
- Reserves who played less than two consecutive weeks of training and matches for either of the respective teams during the current season.

4.3 Training and Match Demand Questionnaire

The questionnaire developed during Study 1 (Appendix A2) measured adolescent cricket players' training and match demand over seven weeks during the 2023 cricket season between February and March. During the seven weeks, participants were asked to complete all relevant sections about their training and match demand daily via the online questionnaire using REDCap electronic data capture tools hosted at The University of the Witwatersrand (Harris et al.,2009; Harris et al., 2019).

The five activities included in the questionnaire were bowling, batting, fielding, strength and conditioning, and "other activities". Other activities were defined as activities which were not cricket-related but contributed to the overall training and match demand for the week for each player, for example, rugby or hockey training.

For all positions of play, the session duration in minutes, RPE score, sRPE and sRPE-based training demand (duration of session X sRPE of session) were measured per session, i.e., per daily session. In addition, specific measures related to each position were included. The type of session (live net, middle practice or match) and total overs bowled per day were considered for bowling. The type of session (live net, middle practice or match) and total deliveries faced were considered for batting. The type of session (field-based, middle practice or match) and the total balls thrown in the session were considered for fielding. For strength and conditioning sessions, the type of session (strength, fitness, speed agility and quickness (SAQ), recovery or rehab) was considered. The session duration, RPE, and session RPE were considered for all “other activities” done.

The sum of the daily sRPE-based training demand scores for an activity from Monday to Friday, relative to the daily sRPE-based training demand scores over the previous 28 days, provided the weekly ACWR for that activity. Thus, ACWR values were obtained per adolescent cricketer for the study's 4th, 5th, 6th and 7th week. Summing the sRPE-based training demand values across the five activities per adolescent cricketer per day yielded a total daily RPE measurement for the combined daily activities of each adolescent cricketer. When divided by the total sRPE-based training demand values of the previous four weeks, the weekly total sRPE-based training demand values provided the ACW ratios per week per adolescent cricketer for the combined activities.

The ACW ratios for the combined activities were calculated based on the original total sRPE-based training demand daily values and the smoothed total sRPE-based training demand daily values. The two smoothing options considered were moving averages (RA) and exponentially weighted moving averages (EWMA). Moving averages were calculated over seven days for weekly (acute) sRPE-based training demand and 28 days for four-weekly (chronic) sRPE-based training demand. Weighted exponential smoothing was calculated over 7, 14, 21 and 28 days.

4.4 Procedure

Permission was granted by the high school’s governing body, Headmaster and Head of Cricket to approach the cricket players of the U/15 A & B, U16 A & B, 2nd, and 1st cricket teams after regular cricket practice at the school to discuss the aims and objective of the research project. Players were invited to participate in the research project voluntarily after assent was obtained by the players and consent from the players' parents or guardians.

During the data collection period, participants were asked to complete all relevant sections about their training and match demand daily. REDCap was used to distribute the online questionnaire (Appendix A2) to all the participants via email or WhatsApp.

Participants were advised to contact the researcher if they needed help filling out the training and match demand questionnaire. The researcher was contacted directly, and the assistance was provided individually. The participants asked questions to ensure accurate data entry and representation of training and match demands.

4.5 Data reduction, analysis and presentation

The pilot study involved 17 participants; results were presented descriptively, and no inferential statistics were employed. The data was divided into three separate sections.

The total time spent on the different aspects associated with adolescent cricket was determined by considering the total number of activity sessions per week and the number of sessions and sporting components of each activity. The components were overs and deliveries for bowling, deliveries faced for batting, balls thrown for fielding, time spent on strength and conditioning, and other sporting activities. Maximum and minimum values were determined, as well as average, mean and median values.

The ACWR and RPE ratings of the adolescent cricketers in the cricket season were determined by considering the total number of activity sessions per week and the number of sessions and sporting components of each activity. The components were overs and deliveries for bowling, deliveries faced for batting, balls thrown for fielding, time spent on strength and conditioning, and other sporting activities. Maximum and minimum values were determined for all RPE for each component, as well as average, mean and median values. ACWR was determined using the EWMA model (Hunter, 1986). Maximum and minimum values were determined for all ACWR for each component, as well as average, mean and median values. The daily RPE values were calculated as the sum of all the activities over a week and averaged for the seven days each week. To calculate the ACWR, the mean of the RPE values for the fourth week was calculated per adolescent cricketer and computed as a ratio to the mean RPE values over the previous 28 days or four weeks.

The ACWR was determined by comparing the original unsmoothed data and smoothed data. Smoothing was done using the EWMA model. This mathematical technique is used for data smoothing, particularly in time series analysis and signal processing. It is designed to reduce noise and fluctuations in data while preserving important trends or patterns. This technique is advantageous when dealing with random variations or noise data. The key to this technique is the weighting function. For each data point in the time series, a weight is assigned based on its position. The weights decrease exponentially when moving further back in time. The weight for each data point is calculated using a decay factor, often denoted as "alpha" (α), which is a value between 0 and 1. The closer α is to 1, the more weight is given to recent data, and the smoother the result will be.

To calculate the EWMA at each time step "t", a weighted average of the data points up to that time step is taken. The formula for the EWMA at time "t" is typically expressed as $EWMAt=\alpha*xt+(1-\alpha)*EWMAt-1$ (Hunter, 1986).

Where:

- \(EWMA_t\) is the exponentially weighted moving average at time "t."
- \(x_t\) is the data point at time "t."
- \(α\) is the smoothing factor (between 0 and 1).

To start the calculation, we require an initial value for the EWMA at time t=0. Depending on the specific application, this can be set to the first data point in the series or any other appropriate value. The calculation is typically performed iteratively for each data point in the series, updating the EWMA at each time step.

This process results in a smoothed time series that responds quickly to recent changes in the data while filtering out high-frequency noise and fluctuations. The choice of the decay factor α controls the degree of smoothing. A smaller α will result in more smoothing, while a larger α will make the smoother more responsive to recent data. Exponentially weighted smoothers are widely used in various fields, including finance, engineering, and environmental monitoring, to analyse and visualise trends in data while removing undesirable noise. The choice of the decay factor α should be carefully considered to strike the right balance between responsiveness to recent data and noise reduction, depending on the specific requirements of your analysis.

However, in this research project, the ACWR is calculated on the original (unsmoothed) data, as many adolescent cricketers did not participate in each activity session, making smoothing problematic.

4.6 Ethical Considerations

The ethical considerations are the same as for Study 1.

4.7 Results Study 2 - Training and match demand in adolescent cricketers was monitored over a 7-week period (Pilot Study)

In this section, we will address the study objectives for Study 2, as stated in Chapter 1. Results for the total time spent on the different aspects associated with adolescent cricket and the RPE and ACWR for all the various aspects related to adolescent cricket. Results are presented descriptively, while no inferential statistics have been employed.

4.7.1 Participants

The pilot study involved a sample of 17 participants. The sample consisted of male adolescent cricket players aged 14 to 18 with a median age of 17. The participants represented the school's U/15 A & B, U16 A & B, 2nd, and 1st cricket side. The sample consisted of bowlers, batters, and all-rounders (proficient in bowling and batting).

4.7.2 The total time spent on the different aspects associated with adolescent cricket

The total number of activity sessions per week and the number of sessions and sporting components of each activity were determined. The components were overs and deliveries for bowling, deliveries faced for batting, balls thrown for fielding, time spent on strength and conditioning, and other sporting activities. All weekly averages were included (Figure 11).

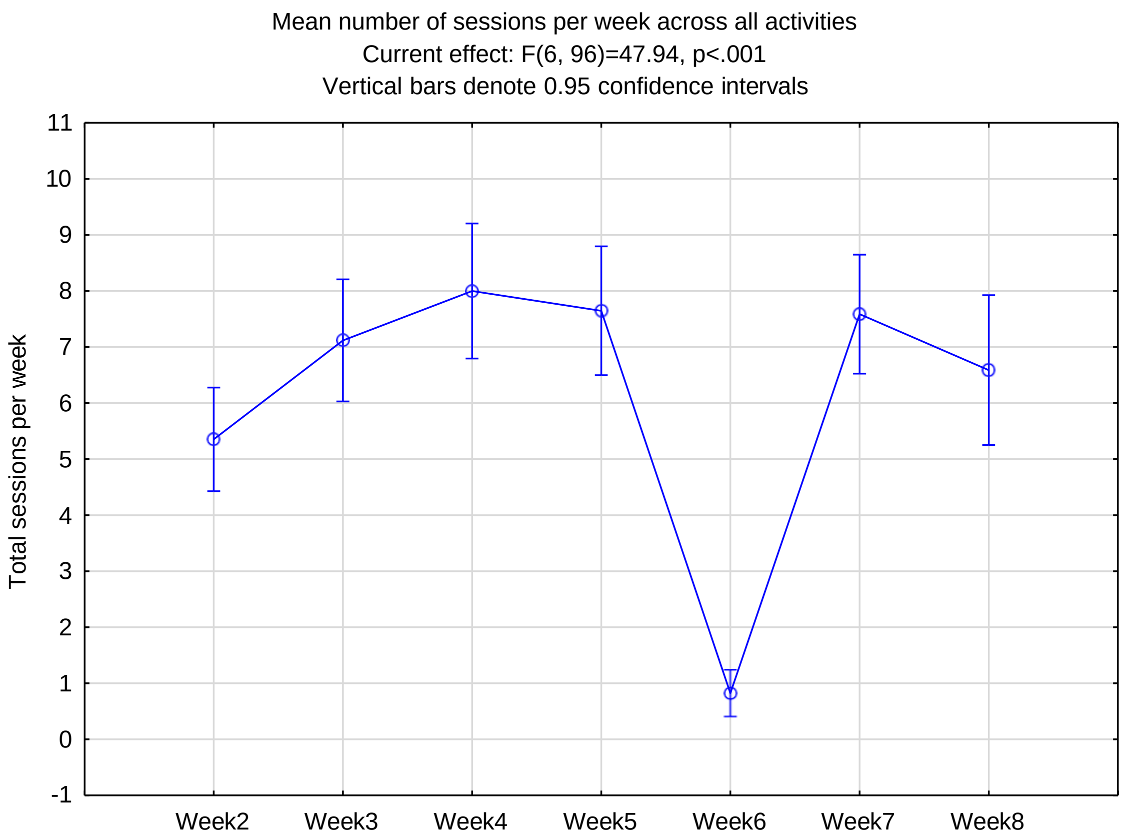

Figure 11. The mean number of sessions per week for the combined activities of the 17 adolescent cricketers

The plot (Figure 11) clearly shows the lack of data in Week 6, when only one session was recorded, compared to an average of 5-8 sessions in the other weeks. Excluding Week 6, the adolescent cricketers' mean number of activity sessions ranged between 5.4 and 8 (Table 9). The lack of data in week 6 was due to adverse weather conditions experienced during the week. Continued rain during the week caused all training areas to be waterlogged, and all training sessions and games were cancelled for the entire week. The school had no indoor facility to continue training. Players reported the lack of training under the comment section provided within the questionnaire; players were encouraged to report any additional remarks or concerns that influenced training during the week. The researcher also made independent observations. It's worth noting that week 1 was not included in the data set, as indicated by Figure 10, which showed the data range from weeks 2 to 8. Training didn't start until Thursday in week 1, leaving less than a week's worth of data. It was, therefore, decided to exclude week 1 from the analysis due to potential effects on ACWR calculations.

Table 9. The mean number of sessions per week across all activities

	Mean	SD	Median	Min	Max
Week 2	5.4	1.8	5	3	9
Week 3	7.1	2.1	7	4	10
Week 4	8.0	2.3	8	5	12
Week 5	7.6	2.2	7	5	11
Week 6	0.8	0.8	1	0	2
Week 7	7.6	2.1	8	5	11
Week 8	6.6	2.6	6	0	11
Total over 7 weeks	43.1	10.7	42	28	64

The supporting data per activity for the adolescent cricketers who participated in that activity is summarised at the group level (Table 10), including and excluding Week 6, and at the individual level in Table 18-23, found in Appendix E.

Bowling

Ten adolescent cricketers provided their bowling details. This was due to players not participating in bowling during training or matches or not considering themselves as bowlers. On average weekly (Table 10), including Week 6, the ten bowlers participated in 3.6 bowling sessions with at most five sessions in a week, bowled on average seven overs, at most 13 overs, with about half the adolescent cricketers bowling seven overs or less per week. On average, per session per week, they recorded 41.8 deliveries and bowled an average of 419 minutes weekly. Averages excluding week six are reported in Table 10.

At the individual level, in Table 19, found in Appendix E, participants bowled between one and five days a week, up to five times a week. The maximum number of overs bowled per day for any of the bowlers was 13, and their total number of overs bowled per week ranged from 49 to 219. Any bowler's maximum number of deliveries per day ranged from 54 to 78.

Batting

Twelve adolescent cricketers provided their batting details. This was due to players not participating in batting during training or matches or not considering themselves as batters. On average, weekly (Table 10), including week 6, the 12 batters participated in 3.5 batting sessions with at most five sessions, with 58.4 deliveries on average, with at most 180 and about half the adolescent cricketers batting 54 or less deliveries per week. Averages excluding week six are reported in Table 10.

At the individual level, Table 20, found in Appendix E, they batted up to five days a week. The maximum number of deliveries per day for any of the 12 adolescent cricketers ranged from 50 to 180.

Fielding

All 17 adolescent cricketers provided their fielding details. On average, weekly (Table 10), including week 6, the 17 adolescent cricketers participated in 1.2 fielding sessions with at most four sessions, with 43.2 balls thrown on average, with at most 150 and about half the adolescent cricketers throwing 40 or less per week. Averages excluding week six are reported in Table 10.

At the individual level, Table 21, found in Appendix E. They fielded up to 4 days a week. The maximum number of balls thrown daily for any 17 adolescent cricketers ranged from 40 to 150.

Strength and conditioning

Eleven adolescent cricketers provided their strength and conditioning (S&C) details. This was due to six players not participating in S&C sessions. On average, weekly (Table 10), the 11 adolescent cricketers participated in 1.7 S&C sessions, with at most two sessions per week. Averages excluding week six are reported in Table 10.

See Appendix E, Table 22, for individual level of participation.

Other sports

Six adolescent cricketers provided details on other sporting activities. On average, weekly (Table 10), including week 6, the six adolescent cricketers participated in 1.4 other sporting sessions, with at most two sessions per week. On average, they spent 90.9. minutes per session, with 150 minutes at most, and about half the adolescent cricketers spend 75 minutes on other sporting activities per week. Averages excluding week six are reported in Table 10.

See Appendix E, Table 23, for individual level of participation.

Table 10. Details of the sessions per activity, per week, with/out Week 6

Activity sessions		Mean	Total number	SD	Min	Max	Median
Bowling (n=10)	Sessions	3.6	427	1.11	1.0	5.0	4.0
	Overs	7.0	36	2.1	1.0	13.0	7.0
	Deliveries	41.8	218	12.7	6.0	78.0	42.0
	Minutes weekly	61	431	136.7	75.0	660.0	440.0
Bowling (excl. Week 6) (n=10)	Sessions	3.3	413	1.02	1.0	5.0	4.0
	Overs	6.9	36	2.1	1.0	13.0	7.0
	Deliveries	41.7	216	12.7	6.0	78.0	42.0
	Minutes weekly	59	419	122.9	75.0	660.0	440.0
Batting (n=12)	Sessions	3.5	511	1.2	1.0	5.0	4.0
	Deliveries	58.4	258	28.8	3.0	180.0	54.0
	Minutes weekly	73	408	144.1	60.0	565.0	440.0
Batting (excl. Week 6) (n=12)	Sessions	3.2	490	1.1	1.0	5.0	4.0
	Deliveries	58.6	255	28.9	3.0	180.0	54.0
	Minutes weekly	70	395	129.9	60.0	565.0	440.0
Fielding (n=17)	Sessions	1.2	693	0.6	1.0	4.0	1.0
	Balls	43.2	92	20.6	8.0	150.0	40.0
	Minutes weekly	74.8	99	89.0	0.0	510.0	45.0

Fielding (excl. Week 6) (n=17)	Sessions	1.2	693	0.6	1.0	4.0	1.0
	Balls	43.2	92	20.6	8.0	150.0	40.0
	Minutes weekly	74.8	99	89.0	0	510.0	45.0
S&C (n=11)	Sessions	1.7	378	0.5	1.0	2.0	2.0
	Minutes weekly	54	68	20.3	30.0	90.0	75.0
S&C (excl. Week 6) (n=11)	Sessions	1.7	378	0.5	1.0	2.0	2.0
	Minutes weekly	54	68	20.3	30.0	90.0	75.0
Other sports (n=6)	Sessions	1.4	231	0.5	1.0	2.0	1.0
	Minutes weekly	33	91	32.9	60.0	150.0	75.0
Other sports (excl. Week 6) (n=6)	Sessions	1.4	189	0.5	1.0	2.0	1.0
	Minutes weekly	27	85	34.1	60.0	150.0	75.0

4.7.3 The Acute:Chronic workload ratios and rate of perceived exertion ratings

Table 11. sRPE per session per activity (n=17) with/out Week 6

sRPE per session	Mean	SD	Min	Max	Median
Bowling	7.41	0.88	5.0	9.0	7.0
Bowling excl. Week 6	7.41	0.88	5.0	9.0	7.0
Batting	7.11	0.84	5.0	9.0	7.0
Batting excl. Week 6	7.12	0.84	5.0	9.0	7.0
Fielding	7.04	0.77	5.0	9.0	7.0
Strength and conditioning	4.24	3.04	1.0	8.0	6.0
Strength and conditioning excl. Week 6	4.21	3.05	1.0	8.0	6.0
Other sports	6.81	1.33	4.0	9.0	7.0
Other sports excl. Week 6	6.81	1.39	4.0	9.0	7.0

sRPE – Sessions Rating of Perceived Exertion (Borg RPE scale 1-10)_

The ACWR (Table 12) was determined by considering the session durations for each activity per week in minutes (Table 13-15), mean sRPE ratings (Table 11). For each activity, the ACWR was calculated on the original (unsmoothed) data, as many adolescent cricketers did not participate in all activity sessions, making smoothing problematic. The supporting data at the adolescent cricketer level is summarised in Tables 13-15 and 24-25 in Appendix F.

Table 12. Unsmoothed ACWR per activity

Unsmoothed ACWR	Mean	SD	Min	Max	Median
Bowling	0.91	0.60	0.00	2.06	1.12
Batting	0.88	0.57	0.00	1.76	1.10
Fielding	0.88	0.65	0.00	2.56	1.05
Strength and conditioning	0.73	0.69	0.00	2.04	0.94
Other sports	1.08	0.49	0.00	2.20	1.01
Total activities	0.92	0.53	0.00	1.69	1.15

ACWR – Acute:Chronic workload ratio.

Bowling

On average, bowling sessions combined took 117.3 minutes per week (Table 13), with half of the sessions taking 90 minutes or less. The mean sRPE recorded per session was 7.4 (SD=0.88, range 5 - 9) (Table 11). The minimum daily sRPE of any bowler was five, and the maximum was 9 (Table 11).

At the individual level (Table 13), the maximum sRPE was nine for most bowlers. The rest did not bowl during the season or score a lower maximum sRPE.

The mean training and match demand for bowling according to the ACWR was 0.91 (SD=0.60, range 0.0 – 2.19), with a maximum ACWR of 2.06 (Table 12). For individual ACWR scores, refer to Table 26 in Appendix F.

Table 13. Summary of bowling session minutes and sRPE per adolescent cricketer (n=17)

Part. number	Bowling minutes					sRPE Bowling sessions			
	Mean per session	Total over 7 weeks	Min per session	Max per session	Median per session	Mean per session	Min per session	Max per session	Median per session
5									
6	119.8	3235	75	210	90	7.6	6	9	7
7	115.2	3341	60	210	90	7.3	6	9	7
8	125.7	2890	85	210	90	7.7	7	9	8
9	125.9	2770	85	210	105	7.4	6	9	7
10	120.7	1810	75	210	105	7.2	5	8	7
11									
12	118.1	3070	75	210	90	7.0	5	9	7
13	115.6	1040	85	210	90	7.7	6	9	8
14									
16									
17									
18									
20									
21	111.1	2555	85	160	105	7.6	7	9	8

22	112.3	2470	85	160	105	7.2	5	9	7
23	109.1	2400	85	160	97.5	7.7	7	9	8

Not all participants provided bowling data. sRPE – Session Rating of Perceived Exertion

Batting

On average, batting sessions combined took 111.7 minutes per week (Table 14), with half the sessions taking 90 minutes or less. The mean sRPE recorded per session was 7.1 (SD=0.84, range 5 - 9) (Table 11). As with bowling, the minimum daily sRPE of any given batter was five, and the maximum was nine (Table 11).

At the individual level (Table 14), the maximum sRPE was nine for most batters. The rest did not bat during the season or scored a lower maximum RPE.

The mean training and match demand for batting according to the ACWR was 0.88 (SD=0.57, range 0,0 - 1,76), with a maximum ACWR of 1.76 (Table 12). For individual ACWR scores, refer to Table 26 in Appendix F.

Table 14. Summary of batting session minutes and sRPE per adolescent cricketer (n=17).

Part. number	Batting minutes					sRPE Batting sessions			
	Mean per session	Total over 7 weeks	Min per session	Max per session	Median per session	Mean per session	Min per session	Max per session	Median per session
5	105.4	2845	75	210	90	7.1	5	8	7
6									
7									
8	87.5	525	60	210	60	6.5	5	8	6.5
9	104.5	1985	35	210	85	6.8	5	9	7
10	122.4	2325	75	210	105	7.2	5	9	7
11	123.6	2720	75	210	97.5	7.1	6	9	7
12	115.0	2761	75	210	90	6.8	5	8	7
13	140.9	2255	75	210	105	7.6	5	9	8
14	110.0	2860	10	210	90	6.9	5	8	7

16	101.6	2845	60	160	90	7.2	6	9	7
17	102.6	2770	60	160	90	7.1	6	8	7
18	112.3	2470	85	160	105	7.4	6	8	7
20	112.3	2470	85	160	105	7.3	6	8	7
21									
22									
23									

Not all participants provided batting data. sRPE – Session Rating of Perceived Exertion

Fielding

On average, fielding sessions combined took 53.2 minutes per week(Table 15). The mean sRPE recorded per session was 6.9 (SD=0.77, range 5 - 9) (Table 11). The minimum daily sRPE of any fielders was five, and the maximum was nine (Table 11).

At the individual level (Table 15), the maximum sRPE was nine for most fielding sessions. The rest did not field during the season or scored a lower maximum RPE.

The mean training and match demand for fielding according to the ACWR was 0.88 (SD=0.65, range 0,0 – 2,56), with a maximum ACWR of 2.56 (Table 12). For individual ACWR scores, refer to Table 26 in Appendix F.

Table 15. Summary of fielding session minutes and sRPE per adolescent cricketer (n=17)

Part. number	Fielding minutes					sRPE Fielding sessions			
	Mean per session	Total over 7 weeks	Min per session	Max per session	Median per session	Mean per session	Min per session	Max per session	Median per session
5	45.0	270	45	45	45	6.5	6	7	6.5
6	45.0	225	45	45	45	7.2	6	9	7
7	45.0	270	45	45	45	6.7	5	8	7
8	45.0	270	45	45	45	6.7	6	7	7
9	45.0	270	45	45	45	6.7	6	7	7
10	45.0	180	45	45	45	6.8	6	8	7
11	120.9	2055	45	210	85	7.4	6	8	8
12	45.0	270	45	45	45	6.3	6	7	6
13	45.0	225	45	45	45	6.4	6	7	6
14	45.0	270	45	45	45	6.8	6	7	7
16	45.0	270	45	45	45	6.8	6	7	7
17	43.3	260	40	45	45	7.0	6	8	7
18	43.3	260	40	45	45	7.2	7	8	7
20	93.0	1395	40	160	85	7.7	6	8	8
21	44.2	265	40	45	45	7.2	6	8	7
22	64.2	385	45	160	45	7.2	6	8	7
23	45.0	270	45	45	45	7.5	7	8	7.5

sRPE – Session Rating of Perceived Exertion

Strength and Conditioning

On average, strength and conditioning sessions took 39.7 minutes per week (Table 24). The mean sRPE recorded per session was 4.2 (SD=3.0, range 1 - 8) (Table 11). The minimum daily sRPE of any strength and conditioning sessions was one, and the maximum was eight (Table 24).

The mean training and match demand for strength and conditioning according to the ACWR was 0.73 (SD=0.69, range 0,0 – 2,09), with a maximum ACWR of 2.04 (Table 12). For individual ACWR scores, refer to Table 26 in Appendix F.

Other sport

Sessions that did not include cricket-related practice, for example, rugby and hockey off-season conditioning work, combined per week, took 63.3 minutes on average (Table 25). The mean sRPE recorded per session was 4,8 (SD=1,3, range 4 - 9). The minimum daily sRPE of any other session was four, and the maximum was nine (Table 11).

At the individual level, the maximum sRPE was nine (Table 25). Most did not do other sports during the cricket season.

The mean training and match demand for other sports, according to the ACWR, was 1.08 (SD=0,49 range 0,0 – 1,61), with a maximum ACWR of 2.20 (Table 12). For individual ACWR scores, refer to Table 26 in Appendix F.

sRPE and ACWR at a group level

Mean sRPE ratings are highest for bowling (M=7.4, SD=0.9) and lowest for strength and conditioning (M=4.2, SD=3.0) (Table 14). Consistently, the unsmoothed mean ACWR was highest for bowling (M=0.9, SD=.6) and lowest for Strength and conditioning (M=0.7, SD=0.7) (Table 12). For the overall unsmoothed ACWR calculated for the sum of all activities, the mean=0.9 with SD=0.5 (Table 26 in Appendix F).

4.7.4 Comparing unsmoothed ACRW values for all activities combined with the corresponding ACWR values with moving averages and exponentially weighted smoothers applied

The daily RPE values were calculated as the sum of all the activities over a week and averaged for the seven days each week. To calculate the ACWR, the mean of the sRPE values for the fourth week was calculated per adolescent cricketer and computed as a ratio to the mean sRPE values over the previous 28 days or four weeks. Week 1 was omitted due to data collection only starting during the middle of the week. The decision was made to omit Week 1 to ensure the 4-week averages were calculated correctly. Therefore, data from Week 2 onwards was used to calculate the ACWR. The ACWR values were calculated similarly for the fifth, sixth and seventh week. This ensured that 4-week averages could be obtained and was ACWR calculated from weeks 2-5, weeks 3-6, and weeks 4-7.

In the case of the exponentially weighted smoother, the number of observations, per person, used to obtain the initial value for recursion was set at 7 days (number of observations) (STATA v17) as higher observation values (14, 21, and 28 days) removed almost all in-person variation in the series.

Initially, the sRPE values of all 49 days were used in the ACWR calculation. However, as the RPE values for Week 6 were mostly zero or near zero, the sRPE values for the four weeks that included Week 6 were suppressed, resulting in unrealistically inflated ACWR ratios (Figure 12). The sRPE values for Week 6 were regarded as missing to avoid this issue. Omitting these values resulted in unsmoothed ACWR values for Weeks 5, 7, and 8 (Days 28, 42, and 49) and a missing unsmoothed value for Week 6 (Day 35). However, the smoothers provided smoothed values for Weeks 2 – 8 without suppressing the ratios.

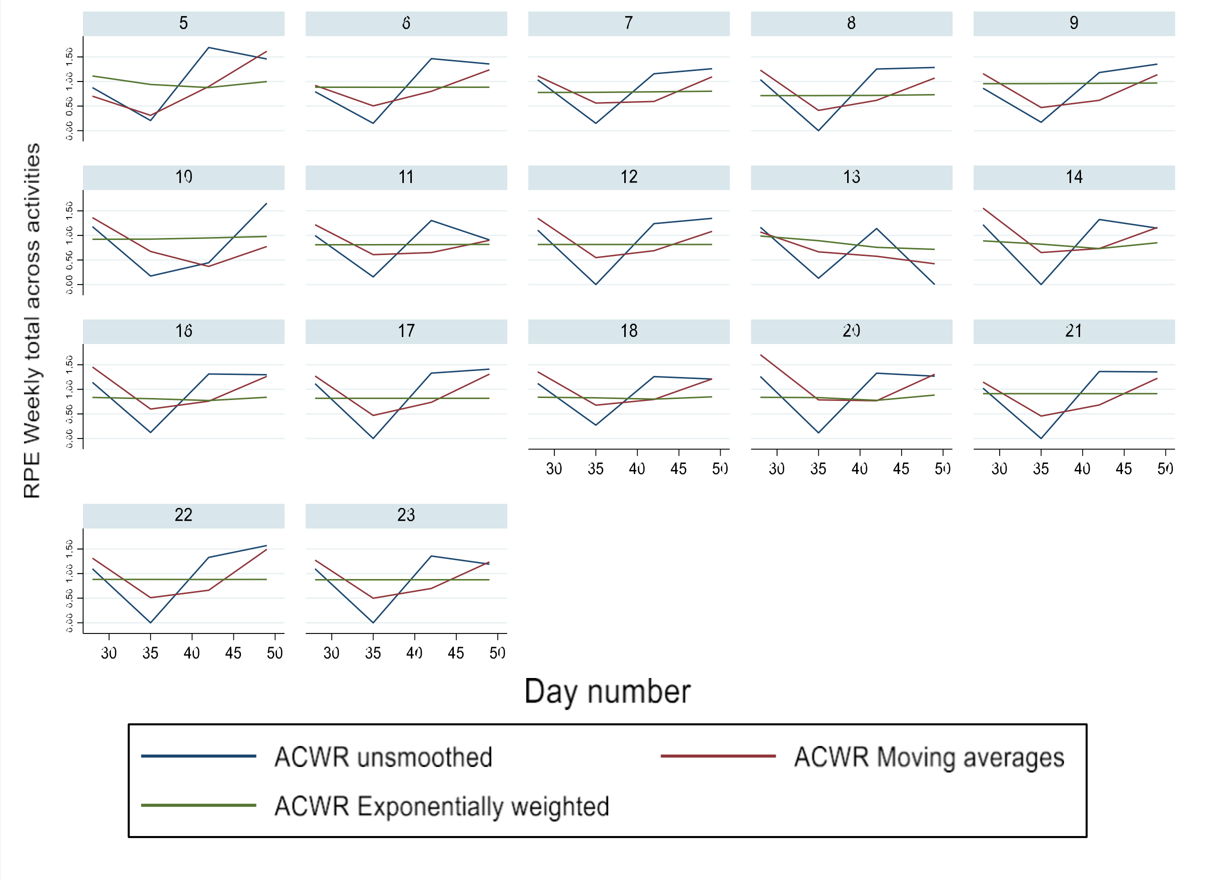

Figure 12. Panel line plots for ACWR unsmoothed and smoothed ratios for combined activities per adolescent cricketer (n=17)

The rationale underlying the exponentially weighted smoother is that newer values are assigned greater weight to the moving average, and older values are assigned less weight based on a coefficient indicating the degree of decay. However, in our data, the degree of decay was near zero (.0001), indicative of almost no decay over the four weeks that involved the ACWR calculation.

Nevertheless, the values of the three sets of ACRW values were plotted and compared as panel line charts for the 17 adolescent cricketers for Day 28 (Week 5), Day 35 (Week 6), Day 42 (Week 7), and Day 49 (Week 8) (Figure 13), and with each panel overlayed on the same graph for these days for the unsmoothed ACWR values (Figure 14), and for the moving averages and exponentially weighted smoothers (Figure 15 and Figure 16, respectively).

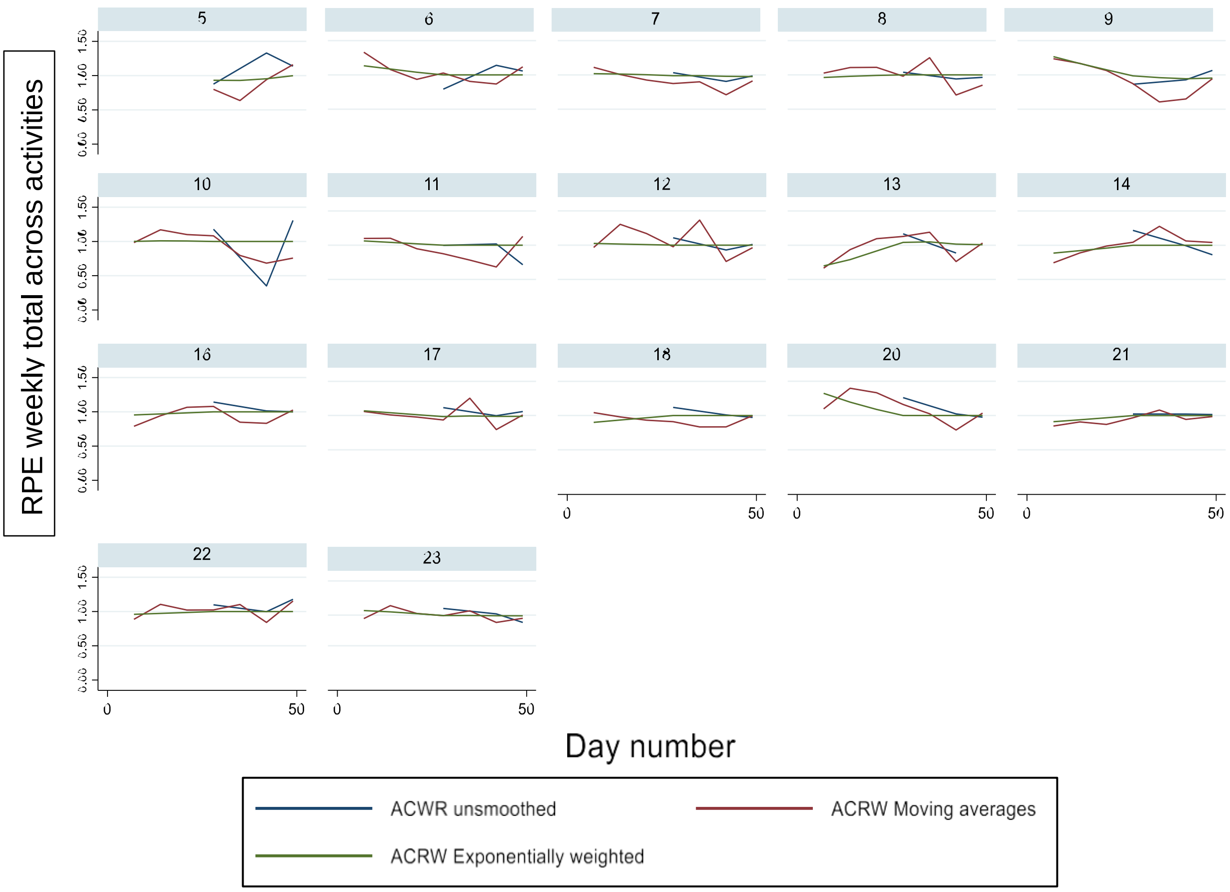

Figure 13. Panel line plots for ACWR unsmoothed and smoothed ratios for combined activities per adolescent cricketer with Week 6 excluded (n=17)

In Figure 13, we can see the comparison between different methods used to calculate ACWR. This includes AWCR using both smoothed and unsmoothed data and the RA model (moving average). The line plots in the figure illustrate the issues that arise when smoothed data is applied to the equation. In particular, the green line appears almost linear, which doesn't accurately reflect the non-linear nature of sports and the daily fluctuations that are typically observed.

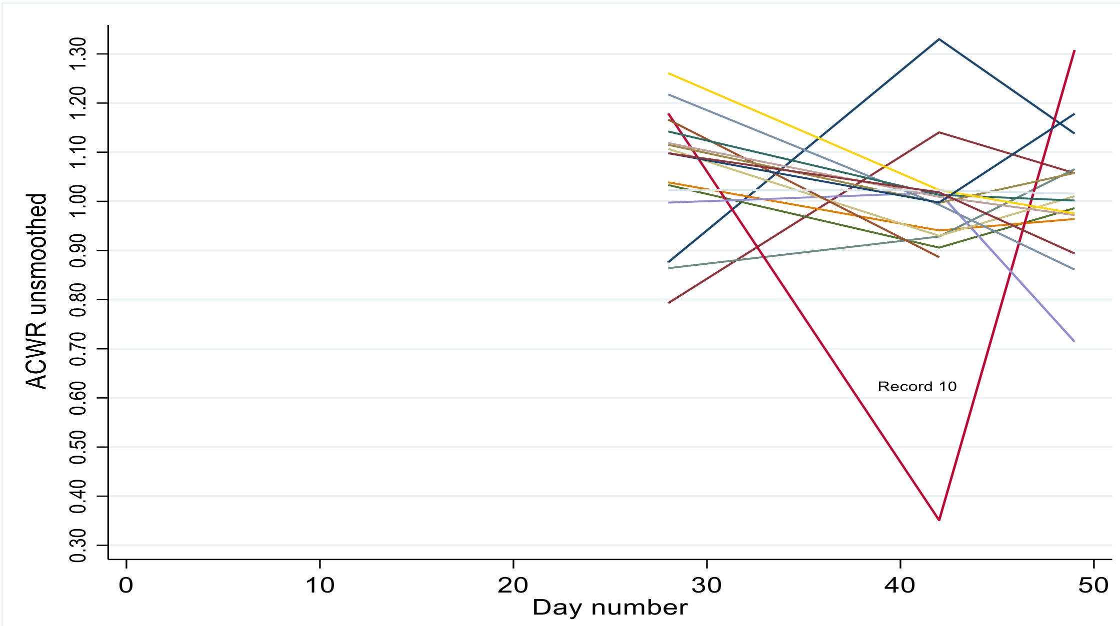

Figure 14. Weekly Acute:Chronic workload ratios for combined activities per individual. Unsmoothed data (n=17)

In Figure 14, the ACWR was calculated using the unsmoothed values, displaying clear daily fluctuations in weekly ratios.

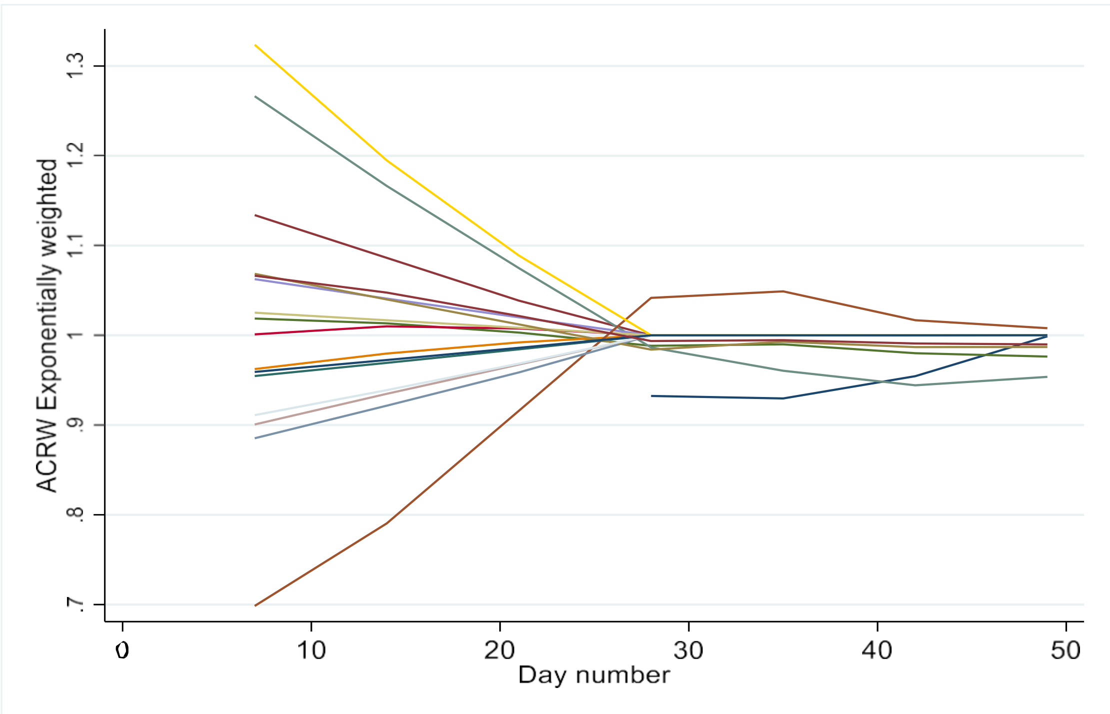

Figure 15. Weekly Acute:Chronic workload ratios for combined activities per individual. Exponential weighted smoothing applied (n=17)

In Figure 15, the plots provide a consistent picture of the relatively extreme smoothing of the exponentially smoothed series (Figure 15), with almost all ACWR values near one and little to no within or between-person variation compared to the corresponding moving averages smoothed values.

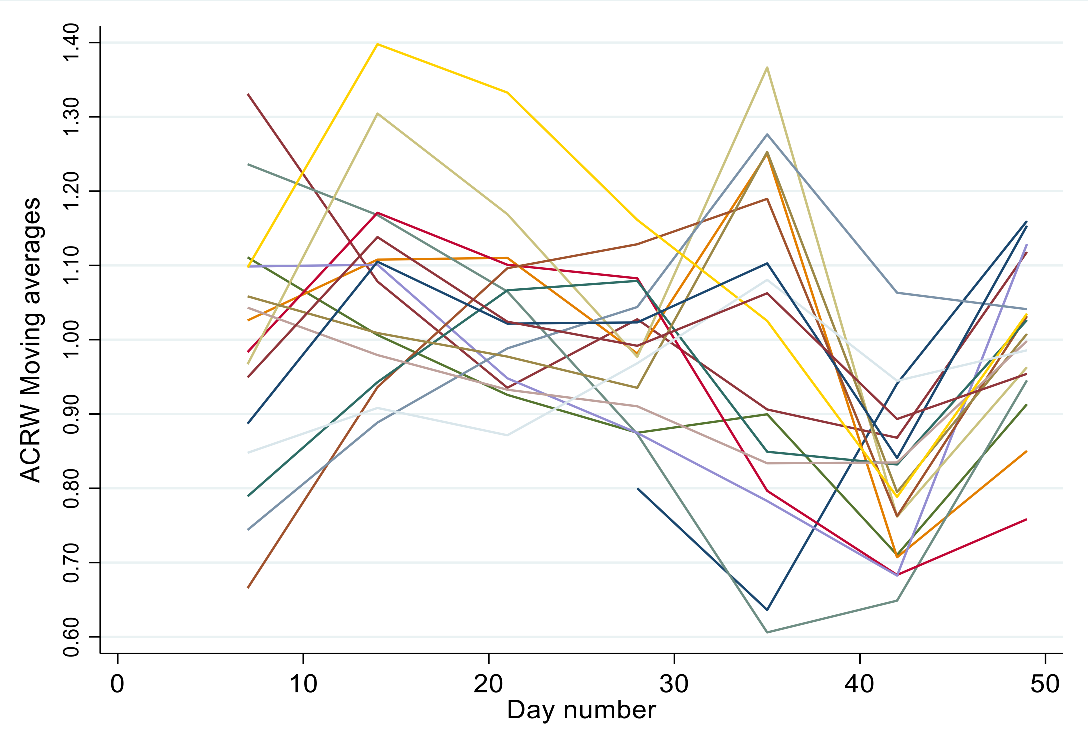

Figure 16. Weekly Acute:Chronic workload ratios for combined activities per individual. Using the RA model (moving average model (n=17)

The analysis presented in Figure 16 involved the calculation of Acute:Chronic Workload Ratios (ACWR) using the RA (rolling average) model. This particular model was more capable of accurately representing the daily variations in training and match intensities.

Finally, the correlations of the unsmoothed, rolling averages and exponentially weighted smoothed values were calculated, and the corresponding scatter diagrams were plotted for each adolescent cricketer in Week 8 (Figure 17 and 18). This was done because smoothing was problematic, as many adolescent cricketers did not participate in each activity session. To determine if there was a significant difference between the unsmoothed, rolling averages and exponentially weighted smoothed values was the data plotted on a scatter diagram to compare the different methods. Considering a single week per adolescent, the cricketer provided a scatter diagram of independent observations as assumed in evaluating the significance of the correlations. The correlations were not significant (p>.05), indicating a lack of consistency.

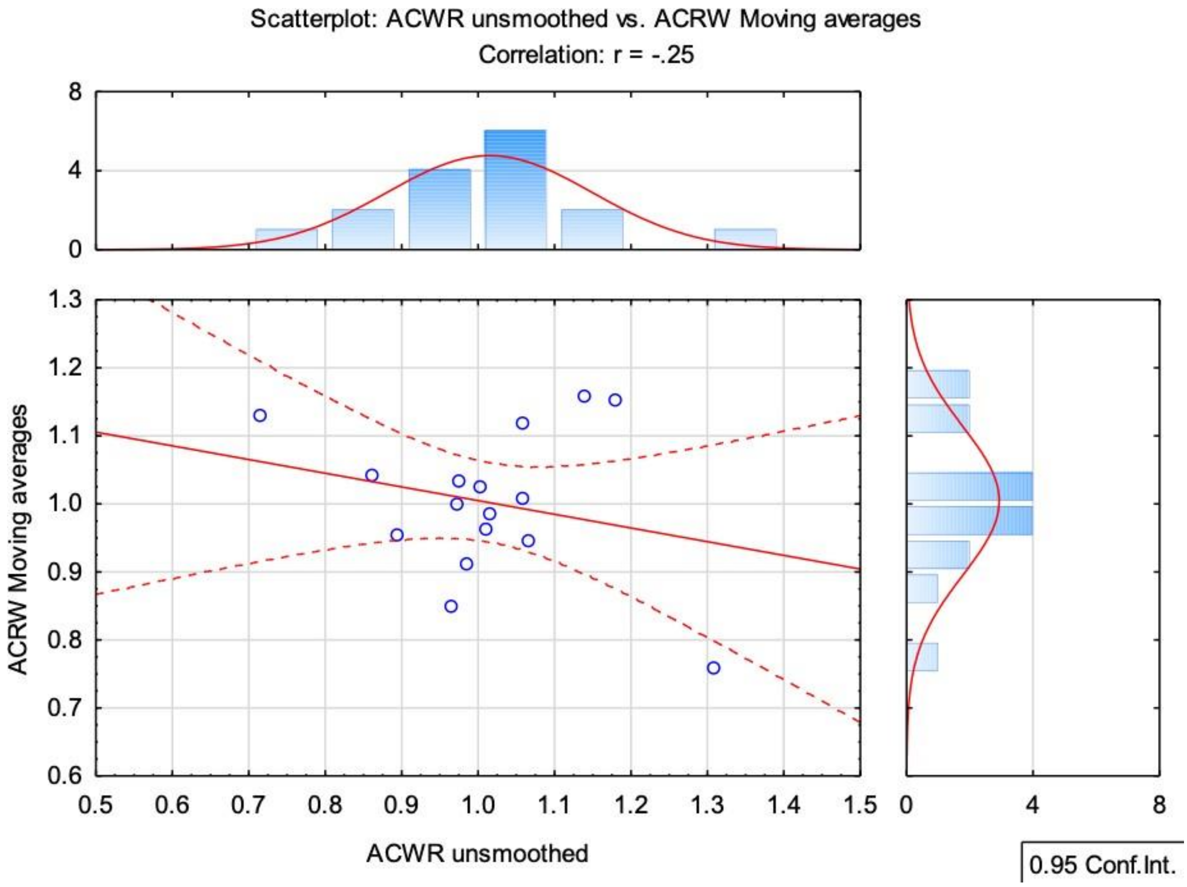

Figure 17. Scatterplot of unsmoothed ACRW values versus moving averages smoothed ACRW for Week 8 (n=17)

Based on the data presented in Figure 17, it can be observed that the majority of values, whether they were unsmoothed or determined by the RA model, fell within the ACWR norm of 0.8-1.3. However, the RA model data showed more variance and were more in line with the nature of sports.

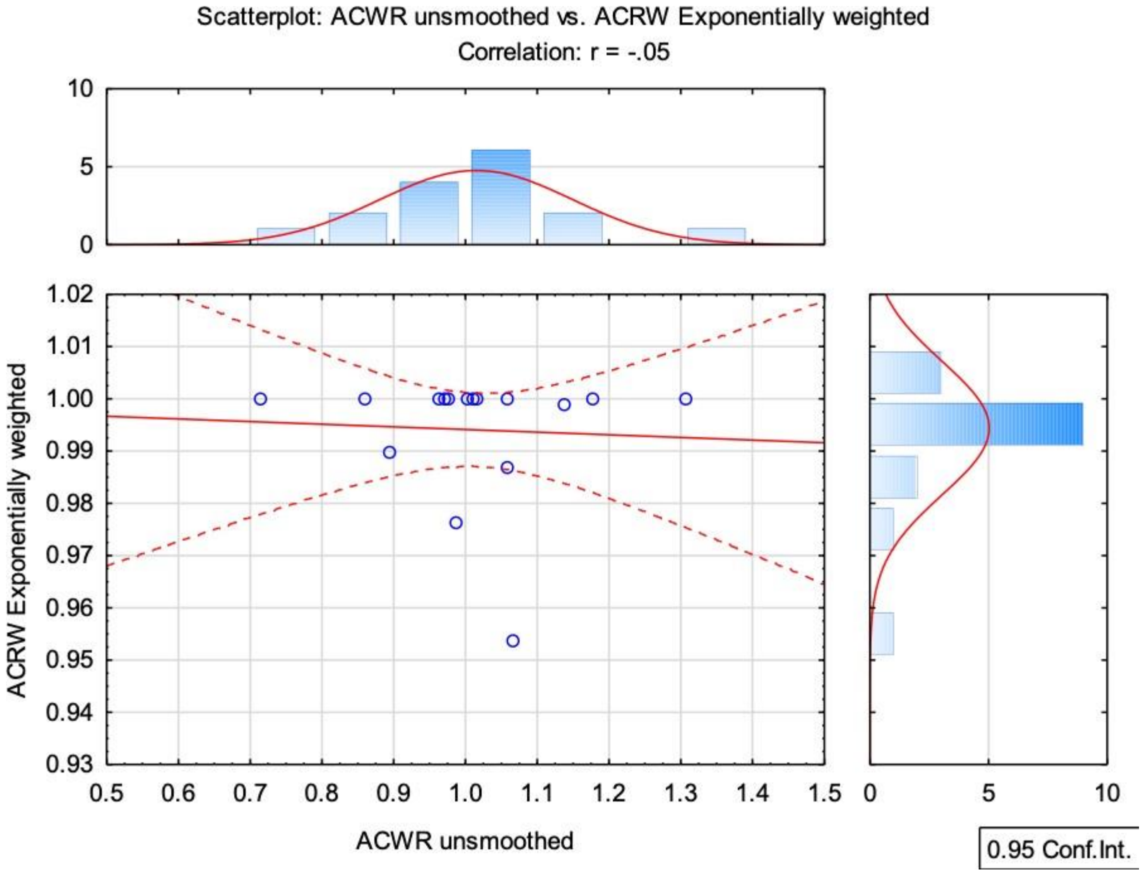

Figure 18. Scatterplot of unsmoothed ACRW values versus exponentially weighted smoothed ACRW values for Week 8 (n=17)

According to the information depicted in Figure 18, it is noticeable that the majority of the values, whether smoothed or unsmoothed, were within the 0.8-1.3 ACWR norm. Nevertheless, the unsmoothed data exhibited more variability, which is more consistent with the nature of sports. Since training involves daily fluctuations, sports cannot be represented by a linear line.

4.7.5 Acute:Chronic workload and injuries

The aim of this pilot study was not to monitor injuries in adolescent cricketers. However, high or low training and match demand can lead to injuries. During the 7-week pilot study, no injuries were reported.

4.8 Discussion

The discussion is divided into three sections, aligning with the study's objectives. The

first section details the time spent on the four aspects associated with cricket, i.e., bowling, batting, fielding, and strength and conditioning, and any other activities or sport done during the week on a responded and group level has been summarised addressing the objectives set out in the research study.

In the second section, the training and match day intensities for all responders on an individual and group level regarding their associated ACW ratios and RPEs are summarised per day, addressing the objectives set out in the research study.

Finally, the third section compares the unsmoothed ACW ratios for the five sporting activities to the corresponding ratios with moving averages and weighted exponential smoothers applied.

4.8.1 The total time spent on the different aspects associated with adolescent cricket

Research has looked into the optimal session duration for certain aspects of cricket, such as the total deliveries allowed to bowl in a training session or per week on an individual and age group level (Cricket Australia, 2023). However, most research has been done on fast bowlers (Christie et al., 2020), and clear guidelines have been set out on how many overs are allowed to be bowled for various age groups per week in training as well as how many overs are allowed to be bowled during matches (Christie et al., 2020).

Ten adolescent cricketers entered their bowling data from the questionnaire. This showed that the bowlers participated in 3.6 bowling sessions per week on average, with the most participating in five sessions per week and bowling on average 7-overs per session (42 deliveries), with the most at 13-overs (78 deliveries). This does cause concerns as the guidelines, as shown in Table 19, for 16–18-year-old players, are between 2-3 sessions per week and 36 deliveries and 42 deliveries per session

(Cricket Australia, 2023). Of the 10 adolescent cricket players, only three were consistently over the norms; on average, the bowling session for the rest was within the norms.

Table 16. Bowling volume guidelines set out by Cricket Australia

Age group	10	11	12	13	14	15	16	17	18	19
Sessions per week	1	1	2	2	2	2	2	3	3	3
Deliveries per session	24	24	24	30	30	30	36	36	42	48

The data includes both match and training sessions within one data set. Data was collected during the in-season of the cricketing calendar, and most weeks consisted of two matches per week, which could account for the extra sessions per week. During a cricket match, on average, an adolescent bowler can deliver between 48 to 60 deliveries per match in a 50-over match and between 12-16 deliveries in a 20-over match. These figures help in assessing the overall bowling demand experienced by individual players. Therefore, to gain an accurate understanding of the physical and mental strain experienced by adolescent bowlers, it is essential to consider these extra sessions from matches. This adds to the overall demand experienced by adolescent cricketers. If this overall demand is not regulated, could this potentially lead to poor performance.

There are clear bowling guidelines for the maximum number of deliveries allowed to be bowled per training session and the number of bowling sessions allowed per week for all age group players (Table 16) (Cricket Australia, 2023). According to the research done by Cricket Australia (2023), these guidelines have been set in place to protect all adolescent bowlers, as they are more susceptible to injuries than players in the other roles associated with cricket (Forrest et al., 2017; Christie et al., 2020). This is clear from the research done by Stretch et al. (2014), showing that 48% more injuries occurred to bowlers over a 5-year period than batting and fielding.

If high training and match demand is maintained longer, it could potentially lead to injuries (Hulin et al., 2013; Forrest et al., 2017). Hulin et al. (2013) investigated whether sudden spikes in training and match demand are associated with injury risk in elite fast bowlers and found that sudden spikes increase the risk of injuries. With the high bowling demand, one could assume that the bowlers were at an increased risk of sustaining an injury and decreased levels of performance. However, a potential limitation of this study was that data was not collected long enough to determine if long-term exposure to high bowling demand could lead to injuries and poor performance. A typical high school cricket season lasts between six to seven months. The study length was only seven weeks, and the long-term effect of sustained exposure to high bowling demand was not determined.

From the data, 17 adolescent cricketers entered their fielding data. On average, weekly, the 17 adolescent cricketers participated in 1.2 fielding sessions with at most 4 sessions, with 43.2 balls thrown on average, with at most 150 and about half the adolescent cricketers throwing 40 or less (Table 21).

There are also no clear guidelines for fielding in cricket; however, related injuries can be high according to the research done by Stretch et al. (2014), who reported that 30% of injuries sustained by adolescent cricketers were associated with fielding during their 5-year investigation. One can adopt the guidelines (Table 17) used in baseball for all fielding done in cricket. Mechanics used to pitch a baseball share some similarities to throwing a cricket ball (Black et al., 2016). The United States of America's Major League Baseball Association (MLB) has set the following standards (Table 17) for the volume of pitches allowed per day in adolescent players (Major League Baseball, 2023). The total pitches done daily will determine the rest needed between sessions.

Table 17. Guidelines on the number of pitches allowed in adolescent baseball (Major League Baseball, 2023)

	Amount of rest needed determined by the number of pitches thrown				
Age	0 Days Rest	1 Days Rest	2 Days Rest	3 Days Rest	4 Days Rest
	Number of pitches done per day				
13-14	1-20	21-35	36-50	51-65	66+
15-16	1-30	31-45	46-60	61-75	76+
17-18	1-30	31-45	46-60	61-80	81+

Table 17 shows the rest that is required for the adolescent cricketer who, on average, threw 43.2 balls per session is two days. The higher number of sessions seen is also due to in-season cricket matches. This is important to note as bowlers will also participate in fielding sessions, and the extra demand from throwing combined with the high demand from fielding can be a cause for concern. This should be further investigated to see if there is any correlation to injuries or poor performance.

There are no clear guidelines for the number of sessions allowed for batting (Christie, 2012). More research is needed on the demand for batting and the impact on injuries. Most injuries from batting can be from direct contact with the ball (Stretch et al., 2014); however, the effects of high training and match demand on batting injuries are not known.

Training and match demand for S&C sessions were very low. The significant variance was due to in-season strength and conditioning sessions. The weekly S&C consisted of two sessions, one dedicated to stretching and recovery.

During the study, the participants were requested to provide data on any additional training or match-related activities that were not exclusively related to cricket. These activities were taken into account to evaluate the weekly training and match demand experience of the adolescent cricket players. However, the study found that there was no significant impact on the "other activities". This can be a limiting factor due to the study's time span.

4.8.2 Acute:Chronic workload ratios (ACWR) and RPE ratings of the adolescent cricketers in the cricket season

The research mentioned in the Literature Review in Chapter 2 has shown that the use of ACWR can be a helpful tool to measure training and match demand and that spikes in acute training and match demand can lead to injuries (Hulin et al., 2015; Bourdon et al., 2017; McNamara et al., 2017; Griffen et al., 2019). Hulin et al. (2015) introduced the concept of an ACWR by measuring the training and match demand in elite cricket fast bowlers. The aim of these studies was to determine if spikes in acute training and match demand could lead to injuries.

The optimal range for the ACWR is context-specific and can vary depending on the sport, athlete, and individual factors (Griffen et al., 2019). Research and expert consensus suggests that maintaining the ACWR within a range of 0.8 to 1.3 is generally associated with reduced injury risk and improved performance outcomes (Hulin et al., 2015; Bourdon et al., 2017; McNamara et al., 2017; Griffen et al., 2019).

In this study, ACWR was determined using the EWMA and RA models. For each activity, the ACWR was calculated on the original (unsmoothed) data, as many adolescent cricketers did not participate in every activity during each session, making smoothing problematic. Using the smoothed values caused inflation of the values, which altered the results.

The ACWR results for all activities fell within the lower end of the norm (0.8). Average ACWRs for different activities were 0.88 for batting, 0.91 for bowling, 0.88 for fielding, 0.73 for strength and conditioning, and the highest reported average of 1.08 was reported for other sports. The average for all activities combined was 0.92. All values are considered within the 'sweet spot' regarding the low risk of sustaining injuries (Bourdon et al., 2017). Some spikes were reported; maximum values ranged from 2,06 for bowling to the lowest spike recorded at 1,76 for batting. This could be due to the high in-season demand of playing multiple weekly games with different formants (T20 and One-day matches).

No injuries were reported during data collection, which can be due to the ACWR being within the safe zone (Bourdon et al., 2017). The load was sufficient to keep the players injury-free. However, the limited time spent collecting data needed to provide more time to see if the recorded spikes in acute training during certain weeks could affect the chronic demand. Also, if data was collected throughout the year, would it be interesting to see how participation in different sports during the off-season affects the player during the latter part of the cricket season? Another reason for the lower ACWR is high training and match demand during the off-season, preparing the players sufficiently to handle the in-season demand. Lowered training and match demand due to in-season demands could also explain the lowered ACWR. A more extended data collection period is needed to fully understand the effects of training and match demand on adolescent cricket players.

4.8.3 Comparing unsmoothed ACRW values for all activities combined with the corresponding ACWR values with moving averages (RA) and exponentially weighted smoothers applied.

There is much debate among researchers as to what the best model to determine the ACWR is (Wang et al., 2020). Most of this disagreement is around the sensitivity to change in these models and that some models are less accurate at providing an accurate ratio that genuinely represents the actual training and match demand (Wang et al., 2020). Hulin et al. (2014) proposed using the EWMA model. The rationale underlying the exponentially weighted smoother is that newer values are assigned greater weight to the moving average, and older values are assigned less weight based on a coefficient indicating the degree of decay, thus being more sensitive to change (Hulin et al., 2014). However, in our data, the degree of decay was near zero at .0001, indicative of almost no decay over the four weeks that involved the ACWR calculation.

Nevertheless, the values of the three sets of ACRW values were plotted and compared as panel line charts for the 17 adolescent cricketers for Day 28 (Week 5), Day 35

(Week 6), Day 42 (Week 7), and Day 49 (Week 8) (Figure 13), and with each panel overlayed on the same graph for these days for the unsmoothed ACWR values (Figure 14), and the moving averages and exponentially weighted smoothers (Figure 15 and figure 16, respectively).

The plots provide a consistent picture of the relatively extreme smoothing of the exponentially smoothed series, with almost all ACWR values near one and little to no within- or between-person variation compared to the corresponding moving averages' smoothed values.

Finally, the correlations of the unsmoothed values, moving averages, and exponentially weighted smoothed values were calculated, and the corresponding scatter diagrams were plotted for each adolescent cricketer in Week 8. Considering a single week per adolescent, the cricketer provided a scatter diagram of independent observations as assumed in evaluating the significance of the correlations. The correlations were insignificant ($p>.05$), indicating a lack of consistency. However, this inconsistency is only sometimes meaningful for diagnostic purposes, as almost all the values are in the standard/acceptable range (0.8-1.3).

4.8.4 Training and Match Demand Questionnaire

The present study aimed to develop and validate a questionnaire to measure adolescent cricket players' training and match demand. The questionnaire was a reliable and valid measure of cricket demand, providing valuable information about players' readiness to train and compete. Notably, to the researcher, this questionnaire is the only one currently available that measures all aspects of adolescent cricket demands and other sports, providing a comprehensive understanding of players' readiness to train and compete.

Further investigation into the questionnaire's predictive ability for injury prevention during cricket season would be fascinating. Due to its ability to measure the demand for cricket, the questionnaire may help identify injuries resulting from over or under-training and determine the relationship between specific injuries and aspects of cricket beyond bowling. In this questionnaire, participants were asked to report an injury sustained during the 7-week period. However, no injuries were reported during this 7-week period. Future questionnaires should include questions regarding injury. This will ensure that a training and match demand questionnaire is used alongside other injury surveillance systems, which will delve deeper into the mechanism, nature, and other aspects of injury and training and match demand.

However, one of the primary challenges encountered during the seven-week study period was noncompliance from participants. This issue impacted both the total number of participants and the use of the exponentially weighted moving average (EWMA) model in determining the ACWR. One potential solution to the issue of noncompliance among adolescent cricketers is to provide education on the importance of monitoring their training and match demands. Moreover, it is recommended that further research be conducted into alternative equations that exhibit similar sensitivity to change as the EWMA yet are less susceptible to the effects of non-compliance. Such investigations may lead to identifying more effective approaches to monitoring and managing training demands in cricket, thereby reducing the risk of injury and improving overall performance.

Chapter 5 Conclusion and Recommendations

5.1 Conclusion

Adolescent sports have become more specialised in recent years due to increased competition, advanced coaching, investment in facilities, the use of sports science and technology, year-round commitment, increased exposure through television and streaming, heightened recruitment efforts, financial considerations, the pressure to win, parental involvement, and the pursuit of scholarships and success. These changes offer opportunities for athletes but also raise concerns about pressure and specialisation at a young age. This has resulted in an increase in training and match demand for all school sports. With the increase in demand, there has been a potential rise in the risk of sustaining injuries from sports. The increase in demand can also lead to chronic fatigue, leading to subsequent burnout. Injuries and burnout can lead to loss of fun and enjoyment in sports. They can lead adolescent players to stop participating in sports, which can further lead to other health risks such as obesity, depression, and other chronic illnesses.

There is a need to monitor the training and match demand of adolescent athletes. The study aimed to develop a valid and reliable questionnaire to monitor the training and match demand in adolescent cricketers. The first objective was achieved by developing a valid and reliable questionnaire for adolescent cricket. This valid and reliable questionnaire will provide coaches and sports scientists a valuable and cost-effective way to monitor adolescent cricket training and match demand. Thus, ensuring long-term participation, preventing over and under-training and minimising the risks of poor performance.

The second aim was achieved through a pilot study that assessed training and match demand by determining the total time spent on the different aspects associated with cricket (bowling, batting, fielding, strength and conditioning) and the number of deliveries bowled, the number of balls faced in a batting session, the total number of balls thrown in a fielding session as well as any other training sessions attended over seven weeks. During the seven weeks, the questionnaire showed that the number of deliveries bowled was on the high end of norms set out by Cricket Australia (2023), potentially leading to poor performance. This, combined with the high throwing volumes from fielding, could further cause concern and poor performance. It also highlighted the need to research the impact of batting demand and its potential effect on performance. Overall, it shows the importance of tracking the total time spent on the different aspects of cricket.

The third objective was to assess training and match demand by determining the rating of perceived exertion (RPE) and Acute:Chronic workload ratios (ACWR) for all the different aspects associated with cricket, as well as any other training sessions done over a 7-week period. Overall, training and match demand for all cricketers, according to the ACWR, were within the lower end of the ratio (average for all activities was 0.92) but still within normal ranges of 0.8-1.3. Some spikes above the ratio were recorded, which could lead to poor performance.

The questionnaire can be used as a valid, reliable and cost-effective way to measure adolescent cricketers' training and match demand. However, the impact of high training and match demand on performance remains unknown. Training and injury prevention questionnaires should be implemented for a more extended period to determine the impact of training and match demand on adolescent cricketers.

5.2 Practical Recommendations

The questionnaire developed in Study 1 and used in Study 2 has been proven to be valid and reliable. It is also a cost-effective method to measure training and match demand as it utilises resources efficiently, provides a positive return on investment, is scalable to various cricket groups, provides good long-term value, has minimal risk and meets the objectives of monitoring training and match demand in sport.

Special care should be taken on the methods used to measure these training and match demand in questionnaires. Various methods and equations are available to measure ACWR in questionnaires, which sometimes can be less sensitive to change, which could lead to the over- and under-prediction of training and match demand.

Coaches and conditioning staff members should compare all available methods according to their strengths, weaknesses, and contextual relevance before implementation into a conditioning program. Tailoring fitness programs to specific goals, needs, and preferences is important. Researching and comparing all methods available to measure training and match demand can help determine the effectiveness and efficiency of the methods used, whether their variability, whether they have scientific validation, whether they have long-term sustainability, and whether adaption and progression are possible.

5.3 Recommendation for Future Research

Future research should focus on using the training and match demand questionnaire to monitor training and match demand over a longer period to fully understand the impact of high and low demand on performance.

Research should also focus on the differences between in-season and off-season training and match demands and the potential impact of these different training and match demands on injuries.

Future studies could explore measuring training and match demand separately or with different methods. The time spent during a cricket match impacts the session RPE (session time x RPE); values are seen as maximal strain; however, RPE might be low, but time spent can be very long. This can be misleading and lead to misinterpretation.

Research suggests using the EWMA model, as it is more sensitive to changes in the ACWR. However, gaps in the data set led to problems with smoothing the data sets. This caused ACWR to be inflated, which will misrepresent the actual training and match demand. Unsmoothed data was used to determine the ACWR, which could also misrepresent the actual training and match demand. Research could focus on how this can be prevented or if other equations allow for better smoothing.

Creating new evidence related to training and match demand could help better understand the impact of training and match demand from different components associated with cricket (bowling, batting, fielding and strength and conditioning), as well as the impact of other sports on the individual players throughout the year. This will provide a better overall picture of the individual and his training.

5.4 Strengths and Limitations

5.4.1 Strengths

The questionnaire measured the training and match demand, and the aims of the research questions were met. The draft questionnaire was developed through an extensive literature review. The literature review focussed on current research and methods that provide valid and reliable data. The questionnaire was based on the recommendations of these researchers.

The draft questionnaire went through a face, content, and test-retest validity process to ensure that it was appropriate for adolescent cricket players. A pilot study was done to test the questionnaire to ensure it could collect the data it set out to collect. The available tool must address cricket and the demands placed on adolescent cricketers and be within the context of adolescent cricket in South Africa. The questionnaire focussed on cricket-specific demands and other factors that would affect the cricketers, such as the effect of strength and conditioning sessions and the effects that other sports could have on the individual.

5.4.2 Limitations

The study's sample size was a limitation in the validity and reliability part of the study. The small sample size had an impact on the content validity score as well as Kendell's W score for reliability. Irrespective, the questionnaire was deemed to be valid and reliable.

The restriction imposed by the Gauteng Education Department limited research allowed in public schools in January in the first term of school or in the fourth term, October to December, in the school year. This narrows the window to research cricket in public schools, which can affect the data collection time, as cricket is mainly played during the first and end of the third and fourth terms. Research for this study was conducted in the first term of school, but this restriction will impact on future studies in cricket.

The method used to determine the ACWR. Research suggests using the EWMA model, as it is more sensitive to changes in the ACWR. However, gaps in the data led to problems with the smoothing of the data sets. This caused ACWR to be inflated, which will misrepresent the actual training and match demand. Unsmoothed data was used to determine the ACWR, which could also misrepresent the training and match demand.

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Appendix

Appendix A1: Training and Match Questionnaire (initial questionnaire)

Match and Training Intensity Questionnaire

Here is you're weekly questionnaire.

Please complete all sections that was relevant to your training for the week.

Thank you for your participation. If you have any question or concerns, please feel free to contact me.

What team do you play for?	______________________
Have you suffered from an injury in the last week (Monday to Sunday)? (if you can't clearly remember whether you reported an injury yet or not, just report it anyway)	◯ Yes ◯ No (Injury definition: any neuromusculoskeletal (muscle, nerve, bone and/or joint) condition which affects your ability to perform during a match or training; this includes any chronic condition which you started the season with, or developed during the season.)
Please specify your type of injury?	______________________
Did you have a bowling session this week? Bowling related questions	◯ Yes ◯ No (If you did not bowl today, mark NO and move on to the next section.)
On which of the following days did you bowl?	☐ Monday ☐ Tuesday ☐ Wednesday ☐ Thursday ☐ Friday ☐ Saturday ☐ Sunday (Only mark the relevant days.)
What type of session was it?	☐ Practice ☐ Match
How many deliveries did you bowl?	______________________ (Only the number)
For how long did you bowl (in minutes)?	______________________ (Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

	Rest	Really easy	Easy	Moderat e	Challen ging	Hard	Hard	Really hard	Really Really hard	Maximu m
Rating of Perceived Exertion Bowling	○	○	○	○	○	○	○	○	○	○

Session RPE Bowling

____

What type of session was it?

☐ Practice
☐ Match

How many deliveries did you bowl?

____
(Only the number)

For how long did you bowl (in minutes)?

____
(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate your bowling session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderat e	Challen ging	Hard	Hard	Really hard	Really Really hard	Maximu m
Rating of Perceived Exertion Bowling	○	○	○	○	○	○	○	○	○	○

Session RPE Bowling

____

What type of session was it?

☐ Practice
☐ Match

How many deliveries did you bowl?

____
(Only the number)

For how long did you bowl (in minutes)?

____
(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate your bowling session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderate	Challenging	Hard	Hard	Really hard	Really Really hard	Maximum
Rating of Perceived Exertion Bowling	○	○	○	○	○	○	○	○	○	○

Session RPE Bowling

____

What type of session was it?

☐ Practice
☐ Match

How many deliveries did you bowl?

____
(Only the number)

For how long did you bowl (in minutes)?

____
(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate your bowling session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderate	Challenging	Hard	Hard	Really hard	Really Really hard	Maximum
Rating of Perceived Exertion Bowling	○	○	○	○	○	○	○	○	○	○

Session RPE Bowling

____

What type of session was it?

☐ Practice
☐ Match

How many deliveries did you bowl?

____
(Only the number)

For how long did you bowl (in minutes)?

____
(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate your bowling session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderate	Challenging	Hard	Hard	Really hard	Really Really hard	Maximum
Rating of Perceived Exertion Bowling	○	○	○	○	○	○	○	○	○	○

Session RPE Bowling

____

What type of session was it?

☐ Practice
☐ Match

How many deliveries did you bowl?

____
(Only the number)

For how long did you bowl (in minutes)?

____
(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate your bowling session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderate	Challenging	Hard	Hard	Really hard	Really Really hard	Maximum
Rating of Perceived Exertion Bowling	○	○	○	○	○	○	○	○	○	○

Session RPE Bowling

____

What type of session was it?

☐ Practice
☐ Match

How many deliveries did you bowl?

____
(Only the number)

For how long did you bowl (in minutes)?

____
(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate your bowling session from 1 - 10. 10 being maximum intensity and 1 being rest										
	Rest	Really easy	Easy	Moderate	Challenging	Hard	Hard	Really hard	Really Really hard	Maximum
Rating of Perceived Exertion Bowling	○	○	○	○	○	○	○	○	○	○

Session RPE Bowling

____

Please rate your overall mood regarding the bowling session										
	Worst	Very Bad	Bad	Meh	So-So	Okay	Good	Very Good	Great	Really Great
Mood statement bowling	○	○	○	○	○	○	○	○	○	○

Did you have a batting session this week?

○ Yes
○ No
(If you did not bat today, mark NO and move on to the next section.)

Batting related questions

On which of the following days did you bat?

☐ Monday
☐ Tuesday
☐ Wednesday
☐ Thursday
☐ Friday
☐ Saturday
☐ Sunday

What type of session was it?

☐ Practice
☐ Match

How many deliveries did you face?

____
(Write down the number only)

For how long did you bat?

____
(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate your batting session from 1 - 10. 10 being maximum intensity and 1 being rest										
	Rest	Really easy	Easy	Moderate	Challenging	Hard	Hard	Really hard	Really Really hard	Maximum
Rating of Perceived Exertion Batting	○	○	○	○	○	○	○	○	○	○

Session RPE Batting

____

What type of session was it?

☐ Practice
☐ Match

How many deliveries did you face?

(Write down the number only)

For how long did you bat?

(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate your batting session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderat e	Challen ging	Hard	Hard	Really hard	Really Really hard	Maximu m
Rating of Perceived Exertion Batting	○	○	○	○	○	○	○	○	○	○

Session RPE Batting

What type of session was it?

☐ Practice
☐ Match

How many deliveries did you face?

(Write down the number only)

For how long did you bat?

(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate your batting session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderat e	Challen ging	Hard	Hard	Really hard	Really Really hard	Maximu m
Rating of Perceived Exertion Batting	○	○	○	○	○	○	○	○	○	○

Session RPE Batting

What type of session was it?

☐ Practice
☐ Match

How many deliveries did you face?

(Write down the number only)

For how long did you bat?

(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate your batting session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderate	Challenging	Hard	Hard	Really hard	Really Really hard	Maximum
Rating of Perceived Exertion Batting	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Session RPE Batting

____

What type of session was it?

☐ Practice
☐ Match

How many deliveries did you face?

____
(Write down the number only)

For how long did you bat?

____
(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate your batting session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderate	Challenging	Hard	Hard	Really hard	Really Really hard	Maximum
Rating of Perceived Exertion Batting	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Session RPE Batting

____

What type of session was it?

☐ Practice
☐ Match

How many deliveries did you face?

____
(Write down the number only)

For how long did you bat?

____
(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate your batting session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderate	Challenging	Hard	Hard	Really hard	Really Really hard	Maximum
Rating of Perceived Exertion Batting	○	○	○	○	○	○	○	○	○	○

Session RPE Batting

____

What type of session was it?

☐ Practice
☐ Match

How many deliveries did you face?

____
(Write down the number only)

For how long did you bat?

____
(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate your batting session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderate	Challenging	Hard	Hard	Really hard	Really Really hard	Maximum
Rating of Perceived Exertion Batting	○	○	○	○	○	○	○	○	○	○

Session RPE Batting

____

Please rate your overall mood regarding the batting session

	Worst	Very Bad	Bad	Meh	So-So	Okay	Good	Very Good	Great	Really Great
Mood Statement Batting	○	○	○	○	○	○	○	○	○	○

Did you have a fielding session this week?

○ Yes
○ No
(If you did not field today, mark NO and move on to the next section.)

Fielding related questions

On which of the following days did you do fielding?

☐ Monday
☐ Tuesday
☐ Wednesday
☐ Thursday
☐ Friday
☐ Saturday
☐ Sunday

What type of session was it?

☐ Practice
☐ Match

How many balls did you throw?

____
(Only the number)

For how long did you field?

____
(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate your fielding session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderate	Challenging	Hard	Hard	Really hard	Really Really hard	Maximum
Rating of Perceived Exertion Fielding	○	○	○	○	○	○	○	○	○	○

Session RPE Fielding

____

What type of session was it?

☐ Practice
☐ Match

How many balls did you throw?

____
(Only the number)

For how long did you field?

____
(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate your fielding session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderate	Challenging	Hard	Hard	Really hard	Really Really hard	Maximum
Rating of Perceived Exertion Fielding	○	○	○	○	○	○	○	○	○	○

Session RPE Fielding

____

What type of session was it?

☐ Practice
☐ Match

How many balls did you throw?

____
(Only the number)

For how long did you field?

____
(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate you session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderat e	Challen ging	Hard	Hard	Really hard	Really Really hard	Maximu m
Rating of Perceived Exertion Fielding				○		○		○		○

Session RPE Fielding

____

What type of session was it?

☐ Practice
☐ Match

How many balls did you throw?

____
(Only the number)

For how long did you field?

____
(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate your fielding session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderat e	Challen ging	Hard	Hard	Really hard	Really Really hard	Maximu m
Rating of Perceived Exertion Fielding				○		○		○		○

Session RPE Fielding

____

What type of session was it?

☐ Practice
☐ Match

How many balls did you throw?

____
(Only the number)

For how long did you field?

____
(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate your fielding session from 1 - 10. 10 being maximum intensity and 1 being rest

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Rating of Perceived Exertion ○ Fielding	○	○	○	○	○		

Session RPE Fielding

____

What type of session was it?

☐ Practice
☐ Match

How many balls did you throw?

____
(Only the number)

For how long did you field?

____
(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate your fielding session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderate	Challenging	Hard	Hard	Really hard	Really Really hard	Maximum
Rating of Perceived Exertion Fielding	○	○	○	○	○	○	○	○	○	○

Session RPE Fielding

____

What type of session was it?

☐ Practice
☐ Match

How many balls did you throw?

____
(Only the number)

For how long did you field?

____
(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate your fielding session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderate	Challenging	Hard	Hard	Really hard	Really Really hard	Maximum
Rating of Perceived Exertion Fielding				○		○		○		○

Session RPE Fielding

____

Please rate your overall mood regarding the fielding session

	Worst	Very Bad	Bad	Meh	So-So	Okay	Good	Very Good	Great	Really Great
Mood Statement Fielding				○		○		○		○

Did you do a strength and conditioning session this week?

S&C related questions

○ Yes
○ No
(If you did not, mark NO and move on to the next section.)

On which of the following days dit you do a strength and conditioning session?

☐ Monday
☐ Tuesday
☐ Wednesday
☐ Thursday
☐ Friday
☐ Saturday
☐ Sunday

What type of session was it?

☐ Weight training
☐ Endurance training
☐ Mixed (weights and running)
☐ Speed Agility and Quickness (SAQ)
☐ Recovery

For how long was the session?

____
(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate your session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderate	Challenging	Hard	Hard	Really hard	Really Really hard	Maximum
Rating of Perceived Exertion S&C	○	○	○		○	○	○	○	○	

Session RPE S&C

____

What type of session was it?

☐ Weight training
☐ Endurance training
☐ Mixed (weights and running)
☐ Speed Agility and Quickness (SAQ)
☐ Recovery

For how long was the session?

____
(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate you session from 1 - 10. 10 being maximum intensity and 1 being rest.

	Rest	Really easy	Easy	Moderate	Challenging	Hard	Hard	Really hard	Really Really hard	Maximum
Rating of Perceived Exertion Strength and Conditioning				○		○		○		○

Session RPE S&C

____

What type of session was it?

- ☐ Weight training
- ☐ Endurance training
- ☐ Mixed (weights and running)
- ☐ Speed Agility and Quickness (SAQ)
- ☐ Recovery

For how long was the session?

____

(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate you session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderate	Challenging	Hard	Hard	Really hard	Really Really hard	Maximum
Rating of Perceived Exertion Strength and Conditioning	○	○	○	○	○	○	○	○	○	○

Session RPE S&C

____

What type of session was it?

- ☐ Weight training
- ☐ Endurance training
- ☐ Mixed (weights and running)
- ☐ Speed Agility and Quickness (SAQ)
- ☐ Recovery

For how long was the session?

____

(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate you session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderate	Challenging	Hard	Hard	Really hard	Really Really hard	Maximum
Rating of Perceived Exertion Strength and Conditioning		○	○		○	○	○	○	○	

Session RPE S&C

____

What type of session was it?	☐ Weight training ☐ Endurance training ☐ Mixed (weights and running) ☐ Speed Agility and Quickness (SAQ) ☐ Recovery
For how long was the session?	____________________ (Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate you session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderate	Challenging	Hard	Hard	Really hard	Really Really hard	Maximum
Rating of Perceived Exertion Strength and Conditioning	○	○	○		○	○	○	○	○	

Session RPE S&C	____________________
What type of session was it?	☐ Weight training ☐ Endurance training ☐ Mixed (weights and running) ☐ Speed Agility and Quickness (SAQ) ☐ Recovery
For how long was the session?	____________________ (Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate you session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderate	Challenging	Hard	Hard	Really hard	Really Really hard	Maximum
Rating of Perceived Exertion Strength and Conditioning	○	○	○	○	○	○	○	○	○	○

Session RPE S&C	____________________
What type of session was it?	☐ Weight training ☐ Endurance training ☐ Mixed (weights and running) ☐ Speed Agility and Quickness (SAQ) ☐ Recovery
For how long was the session?	____________________ (Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate you session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderate	Challenging	Hard	Hard	Really hard	Really Really hard	Maximum
Rating of Perceived Exertion Strength and Conditioning						○		○		

Session RPE S&C

____

Please rate your overall mood regarding the batting session

	Worst	Very Bad	Bad	Meh	So-So	Okay	Good	Very Good	Great	Really Great
Mood Statement S&C	○	○	○			○		○	○	

During this week when did you do any other sport? You can pick multiple days

Other sports related questions

- ☐ Monday
- ☐ Tuesday
- ☐ Wednesday
- ☐ Thursday
- ☐ Friday
- ☐ Saturday
- ☐ Sunday

(This is any other sport besides cricket)

For how long was the session?

____

(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate your session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderate	Challenging	Hard	Hard	Really hard	Really Really hard	Maximum
Rating of Perceived Exertion Other Sport	○	○	○	○	○	○	○	○	○	○

Session RPE S&C

____

For how long was the session?

____

(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate your session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderate	Challenging	Hard	Hard	Really hard	Really Really hard	Maximum
Rating of Perceived Exertion Other Sport	○		○		○	○	○	○	○	

Session RPE S&C

____

For how long was the session?

____

(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate your session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderate	Challenging	Hard	Hard	Really hard	Really Really hard	Maximum
Rating of Perceived Exertion Other Sport	○		○		○		○		○	

Session RPE S&C

____

For how long was the session?

____

(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate your session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderate	Challenging	Hard	Hard	Really hard	Really Really hard	Maximum
Rating of Perceived Exertion Other Sport	○		○		○		○		○	

Session RPE S&C

____

For how long was the session?

____

(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate your session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderate	Challenging	Hard	Hard	Really hard	Really Really hard	Maximum
Rating of Perceived Exertion Other Sport	○		○		○		○		○	

Session RPE S&C

____

For how long was the session?

____

(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate your session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderate	Challenging	Hard	Hard	Really hard	Really Really hard	Maximum
Rating of Perceived Exertion Other Sport	○		○		○		○		○	

Session RPE S&C

____

For how long was the session?

____

(Please enter the number in minutes. for example 90. Do not add the word minutes afterwards)

Please rate your session from 1 - 10. 10 being maximum intensity and 1 being rest

	Rest	Really easy	Easy	Moderate	Challenging	Hard	Hard	Really hard	Really Really hard	Maximum
Rating of Perceived Exertion Other Sport	○		○		○		○		○	

Session RPE S&C

____

Please rate your current mood state with regards to school and social life?

- ☐ Worst
- ☐ Very Bad
- ☐ Bad
- ☐ Meh
- ☐ So-So
- ☐ Okay
- ☐ Good
- ☐ Very Good
- ☐ Great
- ☐ Really Great

Appendix A2: Training and Match Questionnaire (adapted questionnaire after study 1)

The development of a questionnaire to assess training and match demand in adolescent cricketers

Here is you're weekly questionnaire.

Please complete all sections that was relevant to your training for the week.

Thank you for your participation. If you have any question or concerns please feel free to contact me.

What team do you play for?	______________________________
Have you suffered from an injury in the last week (Monday to Sunday)? (if you can't clearly remember whether you reported an injury yet or not, just report it anyway)	◯ Yes ◯ No (Injury definition: any neuromusculoskeletal (muscle, nerve, bone and/or joint) condition which affects your ability to perform during a match or training; this includes any chronic condition which you started the season with, or developed during the season.)
Please specify your type of injury?	______________________________

The following questions are related to all bowling sessions done in the week.

If you did not do any bowling sessions during the WEEK, select NO and move on the the next section

Did you have a bowling session this week?	◯ Yes ◯ No (If you did not bowl this week, mark NO and move on to the next section.)
On which of the following days did you bowl?	☐ Monday ☐ Tuesday ☐ Wednesday ☐ Thursday ☐ Friday ☐ Saturday ☐ Sunday (Only mark the relevant days.)
MONDAY - What type of session was it?	☐ Skills ☐ Live nets ☐ Match
How many overs did you bowl?	______________________________ (Only the number)

Number of deliveries bowled

(No need to complete. Equation will automatically complete)

For how long did you bowl (in minutes)?

(Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Mondays bowling session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Bowling	○	○	○		○	○	○	○		

Session RPE Bowling

(No need to complete. Equation will automatically complete)

TUESDAY - What type of session was it?

☐ Skills
☐ Live nets
☐ Match

How many overs did you bowl?

(Only the number)

How many deliveries did you bowl

(No need to complete. Equation will automatically complete)

For how long did you bowl (in minutes)?

(Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Tuesdays bowling session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Bowling	○		○		○		○			

Session RPE Bowling

(No need to complete. Equation will automatically complete)

WEDNESDAY - What type of session was it?	☐ Skills ☐ Live nets ☐ Matc
How many overs did you bowl?	________________ (Only the number)
How many deliveries did you bowl	________________ (No need to complete. Equation will automatically complete)
For how long did you bowl (in minutes)?	________________ (Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Wednesdays bowling session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Bowling	○		○		○		○		○	

Session RPE Bowling	________________ (No need to complete. Equation will automatically complete)
THURSDAY - What type of session was it?	☐ Skills ☐ Live nets ☐ Match
How many overs did you bowl?	________________ (Only the number)
How many deliveries did you bowl	________________ (No need to complete. Equation will automatically complete)
For how long did you bowl (in minutes)?	________________ (Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Thursdays bowling session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Bowling	○		○		○		○		○	

Session RPE Bowling

____
(No need to complete. Equation will automatically complete)

FRIDAY - What type of session was it?

☐ Skills
☐ Live nets
☐ Match

How many overs did you bowl?

____
(Only the number)

How many deliveries did you bowl

____
(No need to complete. Equation will automatically complete)

For how long did you bowl (in minutes)?

____
(Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Fridays bowling session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Bowling	○		○		○		○		○	

Session RPE Bowling

____
(No need to complete. Equation will automatically complete)

SATURDAY - What type of session was it?

☐ Skills
☐ Live nets
☐ Match

How many overs did you bowl?

____
(Only the number)

How many deliveries did you bowl

____
(No need to complete. Equation will automatically complete)

For how long did you bowl (in minutes)?

(Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Saturdays bowling session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Bowling										

Session RPE Bowling

(No need to complete. Equation will automatically complete)

SUNDAY - What type of session was it?

- ☐ Skills
- ☐ Live nets
- ☐ Match

How many overs did you bowl?

(Only the number)

How many deliveries did you bowl

(No need to complete. Equation will automatically complete)

For how long did you bowl (in minutes)?

(Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Sundays bowling session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Bowling										

Session RPE Bowling

(No need to complete. Equation will automatically complete)

Please rate your overall mood regarding your bowling for the week

	Worst	Very Bad	Bad	Meh	So-So	Okay	Good	Very Good	Great	Really Great
Mood statement bowling	◯		◯		◯		◯		◯	

The following questions are related to all batting sessions done in the week.

If you did not do any batting sessions dring the WEEK, select NO and move on the the next section

Did you have a batting session this week?

◯ Yes
◯ No
(If you did not bat this week, mark NO and move on to the next section.)

On which of the following days did you have a batting session?

☐ Monday
☐ Tuesday
☐ Wednesday
☐ Thursday
☐ Friday
☐ Saturday
☐ Sunday

MONDAY - What type of session was it?

☐ Skills
☐ Live nets
☐ Match

How many deliveries did you face?

____
(Write down the number only)

For how long did you bat?

____
(Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Mondays batting session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Batting	◯		◯		◯		◯			

Session RPE Batting

____
(No need to complete. Equation will automatically complete)

TUESDAY - What type of session was it?

☐ Skills
☐ Live nets
☐ Match

How many deliveries did you face?

____
(Write down the number only)

For how long did you bat?

____
(Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Tuesdays batting session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Batting	○	○	○	○	○	○	○	○	○	○

Session RPE Batting

____
(No need to complete. Equation will automatically complete)

WEDNESDAY - What type of session was it?

- ☐ Skills
- ☐ Live nets
- ☐ Match

How many deliveries did you face?

____
(Write down the number only)

For how long did you bat?

____
(Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Wednesdays batting session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Batting	○	○	○	○	○	○	○	○	○	○

Session RPE Batting

____
(No need to complete. Equation will automatically complete)

THURSDAY - What type of session was it?

- ☐ Skills
- ☐ Live nets
- ☐ Match

How many deliveries did you face?

____
(Write down the number only)

For how long did you bat?

____
(Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Thursdays batting session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Batting	○	○	○	○	○	○	○	○	○	○

Session RPE Batting

____
(No need to complete. Equation will automatically complete)

FRIDAY - What type of session was it?

- ☐ Skills
- ☐ Live nets
- ☐ Match

How many deliveries did you face?

____
(Write down the number only)

For how long did you bat?

____
(Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Fridays batting session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Batting	○	○	○	○	○	○	○	○	○	○

Session RPE Batting

____
(No need to complete. Equation will automatically complete)

SATURDAY - What type of session was it?

- ☐ Skills
- ☐ Live nets
- ☐ Match

How many deliveries did you face?

____
(Write down the number only)

For how long did you bat?

____
(Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Saturdays batting session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Batting										

Session RPE Batting

____
(No need to complete. Equation will automatically complete)

SUNDAY - What type of session was it?

☐ Skills
☐ Live nets
☐ Match

How many deliveries did you face?

____
(Write down the number only)

For how long did you bat?

____
(Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Sundays batting session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Batting	○		○	○	○		○		○	○

Session RPE Batting

____
(No need to complete. Equation will automatically complete)

Please rate your overall mood regarding your batting for this week

	Worst	Very Bad	Bad	Meh	So-So	Okay	Good	Very Good	Great	Really Great
Mood Statement Batting						○		○		

The following questions are related to all fielding sessions done in the week.

If you did not do any fielding sessions during the WEEK, select NO and move on the the next section

Did you have a fielding session this week?

○ Yes
○ No
(If you did not do any fielding this week, mark NO and move on to the next section.)

On which of the following days did you do fielding?

- ☐ Monday
- ☐ Tuesday
- ☐ Wednesday
- ☐ Thursday
- ☐ Friday
- ☐ Saturday
- ☐ Sunday

MONDAY - What type of session was it?

- ☐ Practice
- ☐ Match

How many balls did you throw/catch?

____
(Only the number)

For how long did you field?

____
(Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Mondays fielding session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Fielding										

Session RPE Fielding

____
(No need to complete. Equation will automatically complete)

TUESDAY - What type of session was it?

- ☐ Practice
- ☐ Match

How many balls did you throw/catch?

____
(Only the number)

For how long did you field?

____
(Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Tuesdays fielding session from 1 - 10. 10 questions are related to all fielding sessions done in the week. **intensity and 1 being rest. This is the intensity at what you trained for example 8/10.**

1	2	3	4	5	6	7	8	9	10

Rating of Perceived Exertion (RPE) Fielding

Session RPE Fielding

(No need to complete. Equation will automatically complete)

WEDNESDAY - What type of session was it?

- ☐ Practice
- ☐ Match

How many balls did you throw/catch?

(Only the number)

For how long did you field?

(Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Wednesdays fielding session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Fielding										

Session RPE Fielding

(No need to complete. Equation will automatically complete)

THURSDAY - What type of session was it?

- ☐ Practice
- ☐ Match

How many balls did you throw/catch?

(Only the number)

For how long did you field?

(Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Thursdays fielding session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion Fielding										

Session RPE Fielding

(No need to complete. Equation will automatically complete)

FRIDAY - What type of session was it?

- ☐ Practice
- ☐ Match

How many balls did you throw/catch?

(Only the number)

For how long did you field?

(Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Fridays fielding session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Rating of Perceived Exertion (RPE) Fielding							

Session RPE Fielding

(No need to complete. Equation will automatically complete)

SATURDAY - What type of session was it?

- ☐ Practice
- ☐ Match

How many balls did you throw/catch?

(Only the number)

For how long did you field?

(Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Saturdays fielding session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Fielding										

Session RPE Fielding

(No need to complete. Equation will automatically complete)

SUNDAY - What type of session was it?

- ☐ Practice
- ☐ Match

How many balls did you throw/catch?

(Only the number)

For how long did you field?

(Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Sundays fielding session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Fielding	○	○	○	○	○	○	○	○	○	○

Session RPE Fielding

(No need to complete. Equation will automatically complete)

Please rate your overall mood regarding this weeks fielding sessions

	Worst	Very Bad	Bad	Meh	So-So	Okay	Good	Very Good	Great	Really Great
Mood Statement Fielding		○				○		○		

The following questions are related to all cricket specific strength and conditioning sessions done in the week.

If you did not do any cricket specific stregnth and conditioning sessions during the WEEK, select NO and move on the the next section

Did you do a cricket specific strength and conditioning session this week?

- ○ Yes
- ○ No

(If you did not do any cricket specific strength and conditioning sessions during the week, mark NO and move on to the next section.)

On which of the following days dit you do a cricket specific strength and conditioning session?	☐ Monday ☐ Tuesday ☐ Wednesday ☐ Thursday ☐ Friday ☐ Saturday ☐ Sunday
MONDAY - What type of session was it?	☐ Weight training ☐ Endurance training ☐ Mixed (weights and running) ☐ Speed Agility and Quickness (SAQ) ☐ Recovery ☐ Other {other_exercises}
For how long was the session (minutes)?	______________________________ (Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Mondays cricket specific strength and conditioning session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Strength and Conditioning		○				○		○		

Session RPE Strength and Conditioning	______________________________ (No need to complete. Equation will automatically complete)
TUESDAY - What type of session was it?	☐ Weight training ☐ Endurance training ☐ Mixed (weights and running) ☐ Speed Agility and Quickness (SAQ) ☐ Recovery ☐ Other {other_exercises}
For how long was the session (minutes)?	______________________________ (Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Tuesdays cricket specific strength and conditioning session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Strength and Conditioning	○	○	○		○	○	○	○	○	○

Session RPE S&C

(No need to complete. Equation will automatically complete)

WEDNESDAY - What type of session was it?

- ☐ Weight training
- ☐ Endurance training
- ☐ Mixed (weights and running)
- ☐ Speed Agility and Quickness (SAQ)
- ☐ Recovery
- ☐ Other {other_exercises}

For how long was the session (minutes)?

(Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Wednesdays cricket specific strength and conditioning session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Strength and Conditioning	○	○	○		○	○	○	○	○	○

Session RPE S&C

(No need to complete. Equation will automatically complete)

THURSDAY - What type of session was it?

- ☐ Weight training
- ☐ Endurance training
- ☐ Mixed (weights and running)
- ☐ Speed Agility and Quickness (SAQ)
- ☐ Recovery
- ☐ Other {other_exercises}

For how long was the session (minutes)?

(Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Thursdays cricket specific strength and conditioning session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Strength and Conditioning		○				○		○		

Session RPE S&C

(No need to complete. Equation will automatically complete)

FRIDAY - What type of session was it?	☐ Weight training ☐ Endurance training ☐ Mixed (weights and running) ☐ Speed Agility and Quickness (SAQ) ☐ Recovery ☐ Other {other_exercises}
For how long was the session (minutes)?	____________________ (Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Fridays cricket specific strength and conditioning session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion Strength and Conditioning	○	○	○		○	○	○	○	○	

Session RPE S&C	____________________ (No need to complete. Equation will automatically complete)
SATURDAY - What type of session was it?	☐ Weight training ☐ Endurance training ☐ Mixed (weights and running) ☐ Speed Agility and Quickness (SAQ) ☐ Recovery ☐ Other {other_exercises}
For how long was the session (minutes)?	____________________ (Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Saturdays cricket specific strength and conditioning session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Strength and Conditioning	○		○		○	○	○	○	○	

Session RPE S&C	____________________ (No need to complete. Equation will automatically complete)

SUNDAY - What type of session was it?	☐ Weight training ☐ Endurance training ☐ Mixed (weights and running) ☐ Speed Agility and Quickness (SAQ) ☐ Recovery ☐ Other {other_exercises}
For how long was the session (minutes)?	________________ (Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Sundays cricket specific strength and conditioning session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Strength and Conditioning	◯	◯	◯		◯	◯	◯	◯	◯	

Session RPE S&C	________________ (No need to complete. Equation will automatically complete)

Please rate your overall mood regarding this weeks cricket specific strength and conditioning sessions

	Worst	Very Bad	Bad	Meh	So-So	Okay	Good	Very Good	Great	Really Great
Mood Statement S&C		◯				◯		◯		

The following questions are related to any other sporting sessions or gym sessions done in the week.

These sessions are not related to cricket, for example rugby preseason gym or hockey field session.

If you did not do any other sport OR gym sessions during the WEEK, select NO and move on the the next section

Did you do any other sporting sessions this week?	◯ Yes ◯ No (If you did not do any other sport or gym this week, mark NO and move on to the next section.)

During this week when did you do any other sport?	☐ Monday ☐ Tuesday ☐ Wednesday ☐ Thursday ☐ Friday ☐ Saturday ☐ Sunday (This is any other sport besides cricket)
MONDAY - For how long was the session?	____________________ (Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Mondays session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Other Sport	○	○	○		○		○		○	

Session RPE	____________________ (No need to complete. Equation will automatically complete)
TUESDAY - For how long was the session?	____________________ (Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Tuesdays session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Other Sport		○				○		○		

Session RPE	____________________ (No need to complete. Equation will automatically complete)
WEDNESDAY - For how long was the session?	____________________ (Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Wednesdays session from 1 - 10. 10 being maximum intensity and 1 being. This is the intensity at what you trained for example 8/10.rest

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Other Sport	○		○		○	○	○	○	○	

Session RPE

(No need to complete. Equation will automatically complete)

THURSDAY - For how long was the session?

(Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Thursdays session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Other Sport		○				○		○		

Session RPE

(No need to complete. Equation will automatically complete)

FRIDAY - For how long was the session?

(Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Fridays session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Other Sport		○				○		○		

Session RPE

(No need to complete. Equation will automatically complete)

SATURDAY - For how long was the session?

(Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Saturdays session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Other Sport										

Session RPE

(No need to complete. Equation will automatically complete)

SUNDAY - For how long was the session?

(Please enter the number only, do not add the word minutes afterwards)

Please rate your training intensity for Sundays session from 1 - 10. 10 being maximum intensity and 1 being rest. This is the intensity at what you trained for example 8/10.

	1	2	3	4	5	6	7	8	9	10
Rating of Perceived Exertion (RPE) Other Sport										

Session RPE

(No need to complete. Equation will automatically complete)

Please rate your current mood state with regards to school and social life for the week?

- ☐ Worst
- ☐ Very Bad
- ☐ Bad
- ☐ Meh
- ☐ So-So
- ☐ Okay
- ☐ Good
- ☐ Very Good
- ☐ Great
- ☐ Really Great

Appendix B: Consent form Gauteng Department of Education

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

8/4/4/1/2

GDE RESEARCH APPROVAL LETTER

Date:	**04 May 2022**
Validity of Research Approval:	**08 February 2022– 30 September 2022** **2022/168**
Name of Researcher:	**Grobler,N**
Address of Researcher:	**10 Lunnon Road**
	198 Lunnon Road
	Hillcrest, Pretoria
Telephone Number:	**0833852007**
Email address:	**Nicograbler23@gmail.com**
Research Topic:	**To determine the training and match day intensities of high school cricketers through self-report questionnaire**
Type of qualification	**MSc Med by dissertation**
Number and type of schools:	**Secondary schools**
District/s/HO	**Tshwane south**

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

06/05/2022

The following conditions apply to GDE research. The researcher may proceed with the above study subject to the conditions listed below are met. Approval may be withdrawn should any of the conditions listed below be flouted:

1. *The letter would indicate that the said researcherls has/have been granted permission from the Gauteng Department of Education to conduct the research study.*
2. *The District/Head Office Senior Managerls must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.*
3. ***Because of the relaxation of COVID 19 regulations researchers can collect data online, telephonically, physically access schools, or may make arrangements for Zoom with the school Principal. Requests for such arrangements should be submitted to the GDE Education Research and Knowledge Management directorate.***
4. ***The Researchers are advised to wear a mask at all times, Social distance at all times, Provide a vaccination certificate or negative COV/D-19 test, not older than 72 hours, and Sanitise frequently.***
5. *A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would Indicate that the researcherls has been granted permission from the Gauteng Department of Education to conduct the research study.*
6. *A letter/document that outlines the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs, and District/Head Office Senior Managers of the schools and districts/offices concerned, respectively.*
7. *The Researcher will make every effort to obtain the goodwill and cooperation of all the GDE officials, principals, and chairpersons of the SGBs, teachers, and learners involved. Persons who offer their cooperation will not receive additional remuneration from the Department while those that opt not to participate will not be penalised in any way.*
8. *Research may only be conducted after school hours so that the normal school program is not interrupted. The Principal (if at a school) and/or Director (if at a district/head office) must be consulted about an appropriate time when the researcherls may carry out their research at the sites that they manage.*
9. *Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year. If Incomplete, an amended Research Approval letter may be requested to conduct research In the following year.*
10. *Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GOE. Such research wilt have been commissioned and be paid for by the Gauteng Department of Education.*
11. *It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.*
12. *The researcher is responsible for supplying and utilising his/her research resources, such as stationery, photocopies, transport, faxes, and telephones, and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources.*
13. *The names of the GOE officials, schools, principals, parents, teachers, and learners that participate in the study may not appear In the research report without the written consent of each of these Individuals and/or organisations.*
14. *On completion of the study, the researcher/s must supply the Director: Knowledge Management & Research with one Hard Cover bound and an electronic copy of the research.*
15. *The researcher may be expected to provide short presentations on the purpose, findings, and recommendations of his/her research to both GDE officials and the schools concerned.*
16. *Should the researcher have been involved with research at a school and/or a district/head office level, the Director concerned must also be supplied with a summary of the purpose, findings, and recommendations of the research study.*

The Gauteng Department of Education wishes you well in this important undertaking and looks forward to examining the findings of your research study.

Ki d r ads

ftMll"A""---

Mr. Mukatuni
Acting CE : Education Research and Knowledge Management

DATE: .....0. . . g..

Office of the Director: Education Research and Knowledge Management
?'JIFloor,17 Simmonds Street, Johannesburg, 2001
Tel: (011) 355 0488
Email: Faith.Tshabalala@gauteng.gov.za
Website: www.educatlon.gpg.gov.za

Appendix C: Information and Consent from parents/guardians and Adolescent cricket players

School of Therapeutic Sciences

Study Information and Consent form

This information and consent form will be made available to parents/guardians and cricketers to sign via hard copy or e-consent (REDCap): https://redcap.link/training_intensity

Study title: The development of a questionnaire to assess training and match demand in adolescent cricketers

Dear Cricketer

I am Nico Grobler, and I am studying towards my master's degree to determine high school cricketers' match and training intensities. Training intensity is the volume of training during practice and matches. The assumption would be that should the intensity be too high or too low, it potentially could have a negative effect on your performance. The negative effect of poorly managed training intensities is that it can contribute to more injuries and long-term performance fatigue. On the positive side, well-managed training intensity aims to keep your performance at an optimal level, reducing the risk of injuries. This is important to ensure that you stay injury-free and that performance is retained at the same level each week. In this research project, we will aim to develop a valid and reliable questionnaire measuring the intensity of your training in cricket and any other sport you may participate in during the cricket season.

Information related to the Training Intensity Project:

This study will be done over two periods: Firstly, it will be completed to determine the validity and reliability of the match and training questionnaire during the 2022 cricket season, and if successful, the second part of the study will be implemented during the 2023 cricket season. The second part of the study aims to measure your match and training intensity with the questionnaire developed in the first part.

Who is eligible to take part in this study?

Study 1 (Validity and Reliability Study) - All adolescent cricketers and coaching staff of the 1st and 2nd teams and reserves may enter the teams due to injury. Also, players who are currently not injured and able to participate during the current 2022 season

Study 2 (Main Study) - All adolescent cricketers of the 0/15 A - B, 0/16 A - B, 1st, 2nd and 3rd cricket teams and reserves that may enter these teams due to injury. Thus, players who are not currently injured and able to participate in the 2023 season

What does the study involve?

You will be invited to complete the initial questionnaire at the start of the cricket season, which will take around 5 minutes. A weekly match and training intensity questionnaire will be sent out to you via email at the start of each training week. The match and training intensity questionnaire is a short questionnaire and takes 5-10 minutes to complete. Please contact us if you prefer to complete any questionnaires via hard copy, and we will make special arrangements.

Are there any risks of taking part in this study?

You will not be exposed to any risks. Taking part in the study will also not influence your cricket.

What are the benefits of taking part in this study?

Since I am involved with the school's conditioning and rehabilitation team, the results will assist us in better managing your match and training intensities for continued participation in all sports throughout the year and hopefully prevent over- or undertraining injuries from occurring.

Will access to information be controlled?

When you complete the questionnaires, identifying information, such as name, surname, and email address, will be captured for us to send you follow-up questionnaires throughout the cricket season.

However, in terms of research purposes, only the primary investigator, Nico Grobler, will have access to the raw data, and by the time the data is exported for research analysis, no identifying information will be exported, and all participants will be allocated study numbers. No identifying information will be made public by the researcher.

You can request that your responses be withdrawn from this research study on or before the last day of the previous match of the cricket season in which you completed the questionnaire(s) without suffering any repercussions.

You can contact me, Nico Grobler, at 0640438227 or email s2631174@students.wits.ac.za for further information. For more information on or the reporting of ethical concerns, you may contact the chair of the Human Research Ethics Committee of the University of the Witwatersrand: Dr Clement Penny (Clement.Penny@wits.ac.za); Ms Zanele Ndlovu (Zanele.Ndlovu@wits.ac.za) / Mr Rhulani Mkansi (Rhulani.Mkansi@wits.ac.za); Administrative Officers 011 717 2700/2656/1234/1252.

INFORMED CONSENT FORM: CRICKETER

Study title: The development of a questionnaire to assess training and match demand in adolescent cricketers.

I, Name & Surname:______________________________ e-mail address: ___________________________ and cell phone number:_____________________hereby give consent for my data to be used as stipulated below:

I agree for my data to be used as part of the research project described in the information sheet titled: "**The development of a questionnaire to assess training and match demand in adolescent cricketers**".

☐ Yes

☐ No

I am aware that I can request that my data be withdrawn from this research study on or before the last day of the previous match of the cricket season in which I completed the questionnaire(s) without suffering any repercussions.

☐ Yes

☐ No

I understand that there are no monetary rewards for allowing my data to be used as part of this research study, that participation is voluntary, and that I am not in any way obliged to take part.

☐ Yes

☐ No

Signature of cricketer ___________________________ Date: ______________________

Signature of researcher ________________________

Information related to the use of your data in future research projects

We would like your permission to deposit your data into a research database that will be used for future research by bona fide researchers. Currently, we do not know what the future research questions might be, but if there is any specific topic(s) that you would prefer your data not to be used for, then you can specify this in the consent form. Your data will not be sold for profit, and you can indicate in the consent form if you prefer for your data not to be used in any commercial projects (e.g., device development).

Will access to my data be controlled?

Identifying information, such as your name, surname, and contact details, will be removed from your data, and a study number will be allocated. The link between the study number and the identifying information will be kept in an access-controlled database which will only be accessible by the data manager, access control committee and research group director. If you would like to review the accuracy of your data, feel free to contact the data manager (Nico Grobler via the email address below), who will set up a meeting to verify the information.

Where will my data be stored?

Your data will be stored on a secure platform called REDCap (Research Electronic Data Capture) hosted by the University of the Witwatersrand. This platform is access-controlled and secured on two different servers, and only a data manager, data access committee, and research group director will have access to the data.

How will researchers gain access to my data?

Researchers wanting to use your data in future research projects will apply for ethical clearance. In addition, these applications will be reviewed by a data access control committee in light of the intention of your original consent. If the committee is satisfied with the intended use, access will be granted to your data. Your data might be linked to other datasets and merged with multiple sources. Upon completion of the project, the researcher will be required to upload the modified datasheet onto the REDCap system and remove the copies from his/her computer, whereafter the researcher's access to REDCap will be terminated.

Should you prefer not to allow your data to be used in either the current or future research projects, or both, you will not lose out on any benefits you are entitled to in the absence of this research project. If you would like to withdraw your consent for re-use of your data in future research projects you are free to do so by sending an email to the primary investigator, Nico Grobler (see email address below).

For further information, you are welcome to contact me, Nico Grobler, at 0640438227 or send an email to. For more information on, or for the reporting of ethical concerns, you may contact the chair of the Human Research Ethics Committee of the University of the Witwatersrand: Dr Clement Penny (Clement.Penny@wits.ac.za); Ms Zanele Ndlovu (Zanele.Ndlovu@wits.ac.za) / Mr Rhulani Mkansi (Rhulani.Mkansi@wits.ac.za); Administrative Officers 011 717 2700/2656/1234/1252.

After my name, surname, and contact details have been removed, I agree that my data will be re-used in future research projects without my additional informed consent (tick all that apply).

☐ Yes, my data can be stored and re-used for unlimited time.

☐ Yes, my data can be stored and re-used for a **limited** period of time with an end date specified here: ________________________(DD/MM/YYYY).

☐ Yes, my data can be re-used as part of a project of any type which has been approved by the data access control committee except for topics such as: __________________________________(leave blank if not applicable).

☐ No, I do not agree for my data to be used in future research projects.

Signature of cricketer _________________________ Date: _____________________

Signature of researcher _______________________

Study Information and Consent Form

School of Therapeutic Sciences

This information and consent form will be made available to parents/guardians and cricketers to sign via hard copy or e-consent (REDCap): https://redcap.link/training_intensity

Study title: The development of a questionnaire to assess training and match demand in adolescent cricketers.

Dear Parent/ Guardian

I am Nico Grobler, and I am studying towards my master's degree with the aim of determining the match and training intensities of high school cricketers. Training intensity is the volume of training during practice and matches. The assumption would be that should the intensity be too high or too low, it potentially could have a negative effect on your performance. The negative effect of poorly managed training intensities is that it can contribute to more injuries and long-term performance fatigue. On the positive side, well-managed training intensity's aim is to keep your performance at an optimal level which in turn reduces the risk of injuries. This is important in order to ensure that you stay injury-free and that performance is retained at the same level each week. In this research project, we will aim to develop a valid and reliable questionnaire which will measure the intensity of your training in cricket and any other sport you may participate in during the cricket season.

Information related to the Training Intensity Project:

This study will be done over two periods: Firstly, it will be completed to determine the validity and reliability of the match and training questionnaire during the 2022 cricket season, and if successful, the second part of the study will be implemented during the 2023 cricket season. The aim of the second part of the study is to measure your match and training intensity with the questionnaire that was developed in the first part of the study.

Who is eligible to take part in this study?

Study 1 (Validity and Reliability Study) - All adolescent cricketers and coaching staff of the 1st and 2nd teams as well as reserves may enter the teams due to injury. Also, players who are currently not injured and able to participate during the current 2022 season

Study 2 (Main Study) - All adolescent cricketers from Pretoria Boys High of the 0/15 A - B, 0/16 A - B, 1st, 2nd and 3rd cricket teams and reserves that may enter these teams due to injury. Thus, players who are not currently injured and able to participate in the 2023 season

What does the study involve?

You will be invited to complete the initial questionnaire at the start of the cricket season, which will take around 5 minutes. A weekly match and training intensity questionnaire will be sent out to you via email at the start of each training week. The match and training intensity questionnaire is short and takes 5-10 minutes to complete. Please contact us if you prefer to complete any of the questionnaires via hard copy, and we will make special arrangements.

Are there any risks of taking part in this study?

You will not be exposed to any risks. Taking part in the study will also not influence your cricket.

What are the benefits of taking part in this study?

Since I am involved with the school's conditioning and rehabilitation team, the results will assist us to better manage your match and training intensities for continued participation in all sports throughout the year and hopefully prevent over- or undertraining injuries from occurring.

Will access to information be controlled?

When you complete the questionnaires, identifying information, such as name, surname, and email address, will be captured for us to send you follow-up questionnaires throughout the cricket season.

However, in terms of research purposes, only the primary investigator, Nico Grobler, will have access to the raw data, and by the time the data is exported for research analysis, no identifying information will be exported, and all participants will be allocated study numbers. No identifying information will be made public by the researcher.

You can request that your responses be withdrawn from this research study on or before the last day of the last match of the cricket season in which you completed the questionnaire(s) without suffering any repercussions.

For further information, you can contact me, Nico Grobler, at 0640438227 or email s2631174@students.wits.ac.za. For more information on, or for the reporting of ethical concerns, you may contact the chair of the Human Research Ethics Committee of the University of the Witwatersrand: Dr Clement Penny (Clement.Penny@wits.ac.za); Ms Zanele Ndlovu (Zanele.Ndlovu@wits.ac.za) / Mr Rhulani Mkansi (Rhulani.Mkansi@wits.ac.za); Administrative Officers 011 717 2700/2656/1234/1252.

Nico Grobler
MSc Student
Physiotherapy Department, University of the Witwatersrand

INFORMED CONSENT FORM – <u>GUARDIAN/PARENTS</u> OF CRICKETER

Study title: The development of a questionnaire to assess training and match demand in adolescent cricketers.

I, Name & Surname:______________________________ e-mail address: __________________________ and cell phone number:_____________________hereby give consent for my child's data to be used as stipulated below:

I agree that my child's data will be used as part of the research project described in the information sheet titled: "**The development of a questionnaire to assess training and match demand in adolescent cricketers.**".

☐ Yes

☐ No

I am aware that I can request for my child's data to be withdrawn from this research study on or before the last day of the last match of the cricket season in which I completed the questionnaire(s) without suffering any repercussions.

☐ Yes

☐ No

I understand there are no monetary rewards for allowing my child's data to be used in this research study. Participation is voluntary, and I am not obliged to participate.

☐ Yes

☐ No

Signature of parent/guardian ___________________________ Date: ______________________

Signature of researcher ________________________

Information related to the use of your data in future research projects

We would like your permission to deposit your data into a research database that will be used for future research by bona fide researchers. Currently, we do not know what the future research questions might be, but if there is any specific topic(s) that you would prefer your data not to be used for, then you can specify this in the consent form. Your data will not be sold for profit, and you can indicate in the consent form if you prefer for your data not to be used in any commercial projects (e.g., device development).

Will access to my data be controlled?

Identifying information, such as your name, surname, and contact details, will be removed from your data, and a study number will be allocated. The link between the study number and the identifying information will be kept in an access-controlled database which will only be accessible by the data manager, access control committee and research group director. If you would like to review the accuracy of your data, feel free to contact the data manager (Nico Grobler via the email address below), who will set up a meeting to verify the information.

Where will my data be stored?

Your data will be stored on a secure platform called REDCap (Research Electronic Data Capture) hosted by the University of the Witwatersrand. This platform is access-controlled and secured on two different servers, and only a data manager, data access committee, and research group director will have access to the data.

How will researchers gain access to my data?

Researchers wanting to use your data in future research projects will apply for ethical clearance. In addition, these applications will be reviewed by a data access control committee in light of the intention of your original consent. If the committee is satisfied with the intended use, access will be granted to your data. Your data might be linked to other datasets and merged with multiple sources. Upon completion of the project, the researcher will be required to upload the modified datasheet onto the REDCap system and remove the copies from his/her computer, whereafter the researcher's access to REDCap will be terminated.

Should you prefer not to allow your data to be used in either the current or future research projects, or both, you will not lose out on any benefits you are entitled to in the absence of this research project. If you would like to withdraw your consent to re-use your data in future research projects, you are free to do so by emailing the primary investigator, Nico Grobler (see email address below).

You can contact me, Nico Grobler, at 0640438227 or email me for further information. For more information on, or for the reporting of ethical concerns, you may contact the chair of the Human Research Ethics Committee of the University of the Witwatersrand: Dr Clement Penny (Clement.Penny@wits.ac.za); Ms Zanele Ndlovu (Zanele.Ndlovu@wits.ac.za) / Mr Rhulani Mkansi (Rhulani.Mkansi@wits.ac.za); Administrative Officers 011 717 2700/2656/1234/1252.

I agree that my child's data, after his/her name, surname, and contact details have been removed, to be re-used in future research projects without my additional informed consent (tick all that apply).

☐ Yes, my child's data can be stored and reused for **unlimited** time.

☐ Yes, my child's data can be stored and re-used for a **limited** period of time with an end date specified here: ________________________(DD/MM/YYYY).

☐ Yes, my child's data can be re-used as part of a project of any type which the data access control committee has approved except for topics such as: ___________________________(leave blank if not applicable).

☐ Yes, my child's data can be used in commercial projects (e.g., device development).

☐ No, I do not agree that my data will be used in future research projects.

Signature of parent/guardian ______________________________ Date: ________________________

Signature of researcher ___________________________

School of Therapeutic Sciences

WITS UNIVERSITY

This information and consent form will be made available to parents/guardians and cricketers to sign via hard copy or e-consent (REDCap): https://redcap.link/training_intensity

Study title: The development of a questionnaire to assess training and match demand in adolescent cricketers.

Dear Cricket Coach

I am Nico Grobler, and I am studying towards my master's degree with the aim of determining the match and training intensities of high school cricketers. Training intensity is the volume of training during practice and matches. The assumption would be that should the intensity be too high or too low, it potentially could have a negative effect on your performance. The negative effect of poorly managed training intensities is that it can contribute to more injuries and long-term performance fatigue. On the positive side, well-managed training intensity's aim is to keep your performance at an optimal level which in turn reduces the risk of injuries. This is important in order to ensure that you stay injury-free and that performance is retained at the same level each week. In this research project, we will aim to develop a valid and reliable questionnaire which will measure the intensity of your training in cricket and any other sport you may participate in during the cricket season.

Information related to the Training Intensity Project:

This study will be done over two periods. As a cricket coach, will you only be part of the first part of the research project? We require your valuable input regarding whether the questionnaire is specific to adolescent cricket. This will help determine the validity and reliability of the training and match day questionnaire. This will take part during the 2022 cricket season, and if successful, the second part of the study will be implemented during the 2023 cricket season. The aim of the second part of the study is to measure the training and match day intensities of the adolescent cricketer with the questionnaire developed in the first part of the study.

Who is eligible to take part in this study?

Study 1 (Validity and Reliability Study) - All adolescent cricketers and coaching staff of the 1st and 2nd teams and reserves may enter the teams due to injury. Also, players who are currently not injured and able to participate during the current 2022 season

Study 2 (Main Study) - All adolescent cricketers of the 0/15 A - B, 0/16 A - B, 1st, 2nd and 3rd cricket teams and reserves that may enter these teams due to injury. Thus, players who are not currently injured and able to participate in the 2023 season

What does the study involve?

You will be invited to complete the initial questionnaire at the start of the cricket season, which will take around 5 minutes. Please contact us if you prefer to complete any of the questionnaires via hard copy, and we will make special arrangements.

Are there any risks of taking part in this study?

You will not be exposed to any risks. Taking part in the study will also not influence your cricket.

What are the benefits of taking part in this study?

Since I am involved with the school's conditioning and rehabilitation team, the results will assist us to better manage your match and training intensities for continued participation in all sports throughout the year and hopefully prevent over- or undertraining injuries from occurring.

Will access to information be controlled?

When you complete the questionnaires, identifying information, such as name, surname, and email address, will be captured for us to send you follow-up questionnaires throughout the cricket season.

However, in terms of research purposes, only the primary investigator, Nico Grobler, will have access to the raw data and by the time the data will be exported for research analysis, no identifying information will be exported, and all participants will be allocated study numbers. No identifying information will be made public by the researcher.

You can request for your responses to be withdrawn from this research study on or before the last day of the last match of the cricket season in which you completed the questionnaire(s) without suffering any repercussions.

For further information, you are welcome to contact me, Nico Grobler, on 0640438227 or send an email to s2631174@students.wits.ac.za For more information on, or for the reporting of ethical concerns, you may contact the chair of the Human Research Ethics Committee of the University of the Witwatersrand: Dr Clement Penny (Clement.Penny@wits.ac.za); Ms Zanele Ndlovu (Zanele.Ndlovu@wits.ac.za) / Mr Rhulani Mkansi (Rhulani.Mkansi@wits.ac.za); Administrative Officers 011 717 2700/2656/1234/1252.

Nico Grobler
MSc Student
Physiotherapy Department, University of the Witwatersrand

INFORMED CONSENT FORM: CRICKET COACH

Study title: The development of a questionnaire to assess training and match demand in adolescent cricketers

I, Name & Surname:______________________________ e-mail address: _________________________ and cell phone number:_____________________hereby give consent for my data to be used as stipulated below:

I agree for my data to be used as part of the research project described in the information sheet titled: "**The development of a questionnaire to assess training and match demand in adolescent cricketers**".

☐ Yes

☐ No

I am aware that I can request that my data be withdrawn from this research study on or before the last day of the last match of the cricket season in which I completed the questionnaire(s) without suffering any repercussions.

☐ Yes

☐ No

I understand that there are no monetary rewards for allowing my data to be used as part of this research study, that participation is voluntary, and that I am not in any way obliged to take part.

☐ Yes

☐ No

Signature of cricket coach ___________________________ Date: ______________________

Signature of researcher ________________________

Information related to the use of your data in future research projects

We would like your permission to deposit your data into a research database that will be used for future research by bona fide researchers. Currently, we do not know what the future research questions might be, but if there is any specific topic(s) that you would prefer your data not to be used for, then you can specify this in the consent form. Your data will not be sold for profit, and you can indicate in the consent form if you prefer for your data not to be used in any commercial projects (e.g., device development).

Will access to my data be controlled?

Identifying information, such as your name, surname, and contact details, will be removed from your data, and a study number will be allocated. The link between the study number and the identifying information will be kept in an access-controlled database which will only be accessible by the data manager, access control committee and research group director. If you would like to review the accuracy of your data, feel free to contact the data manager (Nico Grobler via the email address below), who will set up a meeting to verify the information.

Where will my data be stored?

Your data will be stored on a secure platform called REDCap (Research Electronic Data Capture) hosted by the University of the Witwatersrand. This platform is access-controlled and secured on two different servers, and only a data manager, data access committee, and research group director will have access to the data.

How will researchers gain access to my data?

Researchers wanting to use your data in future research projects will apply for ethical clearance. In addition, these applications will be reviewed by a data access control committee in light of the intention of your original consent. If the committee is satisfied with the intended use, access will be granted to your data. Your data might be linked to other datasets and merged with multiple data sources. Upon completion of the project, the researcher will be required to upload the modified datasheet onto the REDCap system and remove the copies from his/her computer, whereafter the researcher's access to REDCap will be terminated.

Should you prefer not to allow your data to be used in either the current or future research projects, or both, you will not lose out on any benefits you are entitled to in the absence of this research project. If you would like to withdraw your consent for re-use of your data in future research projects you are free to do so by sending an email to the primary investigator, Nico Grobler (see email address below).

For further information, you are welcome to contact me, Nico Grobler, at 0640438227 or email me. For more information on, or for the reporting of ethical concerns, you may contact the chair of the Human Research Ethics Committee of the University of the Witwatersrand: Dr Clement Penny (Clement.Penny@wits.ac.za); Ms Zanele Ndlovu (Zanele.Ndlovu@wits.ac.za) / Mr Rhulani Mkansi (Rhulani.Mkansi@wits.ac.za); Administrative Officers 011 717 2700/2656/1234/1252.

After my name, surname, and contact details have been removed, I agree that my data will be re-used in future research projects without my additional informed consent (tick all that apply).

☐ Yes, my data can be stored and reused for **unlimited** time.

☐ Yes, my data can be stored and re-used for a **limited** period of time with an end date specified here: ________________________(DD/MM/YYYY).

☐ Yes, my data can be re-used as part of a project of any type which the data access control committee has approved except for topics such as: ___________________________________(leave blank if not applicable).

☐ No, I disagree that my data will be used in future research projects.

Signature of cricket coach__________________________ Date: _____________________

Signature of researcher ________________________

Appendix D: Adolescent cricketer-level summary of the number of sessions and components of each activity.

Table 18. Number of sessions per activity per week per adolescent cricketer (n=17)

	Sessions					
Record/ week	**Bowling**	**Batting**	**Fielding**	**Strength condition**	**Other sports**	**Total**
Participant 5	0	27	6	12	0	45
W2	0	4	1	2	0	7
W3	0	4	1	2	0	7
W4	0	4	1	2	0	7
W5	0	4	1	2	0	7
W6	0	1	0	0	0	1
W7	0	5	1	2	0	8
W8	0	5	1	2	0	8
Participant 6	27	0	5	10	0	42
W2	3	0	1	2	0	6
W3	5	0	1	2	0	8
W4	5	0	1	2	0	8
W5	4	0	0	1	0	5
W6	1	0	0	0	0	1
W7	5	0	1	2	0	8
W8	4	0	1	1	0	6
Participant 7	29	0	6	11	0	46
W2	3	0	1	1	0	5
W3	5	0	1	2	0	8
W4	5	0	1	2	0	8
W5	5	0	1	2	0	8
W6	1	0	0	0	0	1
W7	5	0	1	2	0	8
W8	5	0	1	2	0	8
Participant 8	23	6	6	8	0	43
W2	3	0	1	0	0	4
W3	4	2	1	1	0	8
W4	4	1	1	2	0	8
W5	4	1	1	2	0	8
W6	0	0	0	0	0	0

	Sessions					
Record/ week	**Bowling**	**Batting**	**Fielding**	**Strength condition**	**Other sports**	**Total**
W7	4	1	1	2	0	8
W8	4	1	1	1	0	7
Participant 9	22	19	6	11	6	64
W2	3	3	1	2	0	9
W3	3	3	1	2	1	10
W4	4	4	1	2	1	12
W5	4	2	1	2	1	10
W6	0	1	0	0	1	2
W7	4	3	1	1	1	10
W8	4	3	1	2	1	11
Participant 10	15	19	5	5	8	52
W2	2	3	1	0	0	6
W3	2	3	1	1	0	7
W4	3	4	1	2	1	11
W5	3	4	1	1	2	11
W6	0	0	0	0	2	2
W7	1	1	1	1	1	5
W8	4	4	0	0	2	10
Participant 11	0	22	17	9	6	54
W2	0	3	2	1	0	6
W3	0	3	4	2	1	10
W4	0	5	3	2	1	11
W5	0	4	3	2	1	10
W6	0	0	0	0	2	2
W7	0	5	4	2	0	11
W8	0	2	1	0	1	4
Participant 12	26	24	6	5	0	61
W2	3	3	1	0	0	7
W3	4	3	1	2	0	10
W4	5	5	1	1	0	12
W5	5	4	1	1	0	11
W6	0	0	0	0	0	0
W7	5	4	1	1	0	11
W8	4	5	1	0	0	10

	Sessions					
Record/ week	**Bowling**	**Batting**	**Fielding**	**Strength condition**	**Other sports**	**Total**
Participant 13	9	16	5	10	10	50
W2	1	3	1	2	2	9
W3	2	3	1	2	2	10
W4	1	3	1	2	2	9
W5	3	4	1	2	1	11
W6	0	0	0	0	1	1
W7	2	3	1	2	2	10
W8	0	0	0	0	0	0
14	0	26	6	8	0	40
W2	0	2	1	0	0	3
W3	0	5	1	2	0	8
W4	0	5	1	2	0	8
W5	0	5	1	1	0	7
W6	0	0	0	0	0	0
W7	0	5	1	2	0	8
W8	0	4	1	1	0	6
16	0	28	6	2	0	36
W2	0	3	1	1	0	5
W3	0	4	1	1	0	6
W4	0	5	1	0	0	6
W5	0	5	1	0	0	6
W6	0	1	0	0	0	1
W7	0	5	1	0	0	6
W8	0	5	1	0	0	6
17	0	27	6	0	0	33
W2	0	3	1	0	0	4
W3	0	4	1	0	0	5
W4	0	5	1	0	0	6
W5	0	5	1	0	0	6
W6	0	0	0	0	0	0
W7	0	5	1	0	0	6
W8	0	5	1	0	0	6
18	0	22	6	0	12	40
W2	0	3	1	0	0	4

	Sessions					
Record/ week	**Bowling**	**Batting**	**Fielding**	**Strength condition**	**Other sports**	**Total**
W3	0	3	1	0	2	6
W4	0	4	1	0	2	7
W5	0	4	1	0	2	7
W6	0	0	0	0	2	2
W7	0	4	1	0	2	7
W8	0	4	1	0	2	7
20	0	22	15	0	5	42
W2	0	3	1	0	0	4
W3	0	3	2	0	0	5
W4	0	4	3	0	1	8
W5	0	4	3	0	1	8
W6	0	0	0	0	1	1
W7	0	4	3	0	1	8
W8	0	4	3	0	1	8
Participant 21	23	0	6	0	0	29
W2	3	0	1	0	0	4
W3	4	0	1	0	0	5
W4	4	0	1	0	0	5
W5	4	0	1	0	0	5
W6	0	0	0	0	0	0
W7	4	0	1	0	0	5
W8	4	0	1	0	0	5
Participant 22	22	0	6	0	0	28
W2	3	0	1	0	0	4
W3	3	0	1	0	0	4
W4	4	0	1	0	0	5
W5	4	0	1	0	0	5
W6	0	0	0	0	0	0
W7	4	0	1	0	0	5
W8	4	0	1	0	0	5
Participant 23	22	0	6	0	0	28
W2	3	0	1	0	0	4
W3	3	0	1	0	0	4
W4	4	0	1	0	0	5

	Sessions					
Record/ week	**Bowling**	**Batting**	**Fielding**	**Strength condition**	**Other sports**	**Total**
W5	4	0	1	0	0	5
W6	0	0	0	0	0	0
W7	4	0	1	0	0	5
W8	4	0	1	0	0	5

Table 19. Bowling sessions per participant

Part. number	Bowling sessions					Bowling overs					Bowling deliveries				
	Mean per week	Total over 7 weeks	Min per week	Max per week	Median per week	Mean per session	Total over 7 weeks	Min per session	Max per session	Median per session	Mean per session	Total over 7 weeks	Min per session	Max per session	Median per session
5	0.0	0	0	0	0										
6	3.9	27	1	5	4	7.5	202	4	10	8	44.9	1212	24	60	48
7	4.1	29	1	5	5	7.6	219	4	10	8	45.3	1314	24	60	48
8	3.3	23	0	4	4	6.7	154	2	10	7	40.2	924	12	60	42
9	3.1	22	0	4	4	6.4	140	2	10	6	38.2	840	12	60	36
10	2.1	15	0	4	2	6.4	96	1	13	6	38.4	576	6	78	36
11	0.0	0	0	0	0										
12	3.7	26	0	5	4	7.6	197	4	10	8	45.5	1182	24	60	48
13	1.3	9	0	3	1	5.4	49	1	9	6	32.7	294	6	54	36
14	0.0	0	0	0	0										
16	0.0	0	0	0	0										
17	0.0	0	0	0	0										
18	0.0	0	0	0	0										
20	0.0	0	0	0	0										
21	3.3	23	0	4	4	7.0	160	4	10	7	41.7	960	24	60	42
22	3.1	22	0	4	4	6.7	147	3	9	7	40.1	882	18	54	42
23	3.1	22	0	4	4	7.0	153	4	9	8	41.7	918	24	54	48

Not all participants provided bowling data. This was due to players not participating in bowling during training or matches or not considering themselves as bowlers.

Table 20. Batting sessions per participant

Part. number	Batting sessions					Batting deliveries				
	Mean per week	Total over 7 weeks	Min per week	Max per week	Median per week	Mean per session	Total over 7 weeks	Min per session	Max per session	Median per session
5	3.9	27	1	5	4	53.4	1441	3	126	60
6	0.0	0	0	0	0					
7	0.0	0	0	0	0					
8	0.9	6	0	2	1	40.7	244	30	50	40
9	2.7	19	1	4	3	44.0	836	12	96	40
10	2.7	19	0	4	3	67.1	1274	12	180	66
11	3.1	22	0	5	3	72.7	1600	30	180	66
12	3.4	24	0	5	4	51.5	1236	6	90	48
13	2.3	16	0	4	3	58.5	936	18	120	66
14	3.7	26	0	5	5	63.9	1662	6	180	63
16	4.0	28	1	5	5	59.1	1656	12	180	48
17	3.9	27	0	5	5	58.6	1582	24	120	54
18	3.1	22	0	4	4	56.1	1235	5	90	57
20	3.1	22	0	4	4	62.5	1374	12	126	57
21	0.0	0	0	0	0					

22	0.0	0	0	0	0					
23	0.0	0	0	0	0					

Not all participants provided batting data. This was due to players not participating in batting during training or matches or not considering themselves as batters.

Table 21. Fielding sessions per participant

Part. number	Fielding sessions					Balls fielded				
	Mean per week	Total over 7 weeks	Min per week	Max per week	Median per week	Mean per session	Total over 7 weeks	Min per session	Max per session	Median per session
5	0.9	6	0	1	1	40.8	245	35	45	40
6	0.7	5	0	1	1	35.4	177	30	50	32
7	0.9	6	0	1	1	36.2	217	30	42	37.5
8	0.9	6	0	1	1	39.2	235	35	42	40
9	0.9	6	0	1	1	43.3	260	30	50	45
10	0.7	5	0	1	1	46.0	230	35	55	50
11	2.4	5	0	4	3	118.0	590	80	150	120
12	0.9	6	0	1	1	44.2	265	30	55	45
13	0.7	5	0	1	1	38.0	190	30	45	40
14	0.9	6	0	1	1	45.8	275	30	50	50
16	0.9	6	0	1	1	33.3	200	28	40	31
17	0.9	6	0	1	1	39.2	235	35	45	40

18	0.9	6	0	1	1	37.5	225	35	45	35
20	2.1	0	0	3	3					
21	0.9	6	0	1	1	35.0	210	30	40	35
22	0.9	6	0	1	1	33.8	203	8	45	37.5
23	0.9	6	0	1	1	36.7	220	30	45	37.5

Table 22. Strength and Conditioning sessions

Part. number	Strength and conditioning sessions				
	Mean per week	Total over 7 weeks	Min per session	Max per session	Median per session
5	1.7	12	0	2	2
6	1.4	10	0	2	2
7	1.6	11	0	2	2
8	1.1	8	0	2	1
9	1.6	11	0	2	2
10	0.7	5	0	2	1
11	1.3	9	0	2	2
12	0.7	5	0	2	1
13	1.4	10	0	2	2
14	1.1	8	0	2	1
16	0.3	2	0	1	0
17	0.0	0	0	0	0
18	0.0	0	0	0	0
20	0.0	0	0	0	0
21	0.0	0	0	0	0
22	0.0	0	0	0	0
23	0.0	0	0	0	0

Table 23. Other sports sessions

Part. number	Other sports sessions				
	Mean per session	Total over 7 weeks	Min per session	Max per session	Median per session
5	0.0	0	0	0	0
6	0.0	0	0	0	0
7	0.0	0	0	0	0
8	0.0	0	0	0	0
9	0.9	6	0	1	1
10	1.1	8	0	2	1
11	0.9	6	0	2	1
12	0.0	0	0	0	0
13	1.4	10	0	2	2
14	0.0	0	0	0	0
16	0.0	0	0	0	0

17	0.0	0	0	0	0
18	1.7	12	0	2	2
20	0.7	5	0	1	1
21	0.0	0	0	0	0
22	0.0	0	0	0	0
23	0.0	0	0	0	0

Appendix E: Adolescent cricketer-level summary of each activity's session duration and RPE.

Table 24. Summary of strength and conditioning session minutes and sRPE per adolescent cricketer (n=17)

Part. number	Strength and conditioning minutes					sRPE Strength and conditioning sessions			
	Mean per session	Total over 7 weeks	Min per session	Max per session	Median per session	Means	Min	Max	Median
5	45.0	540	45	45	45	4.2	1	8	4
6	45.0	450	45	45	45	4.6	1	8	6.5
7	45.0	495	45	45	45	4.2	1	8	4
8	37.5	300	30	45	37.5	4.4	1	7	7
9	36.8	405	30	45	30	3.8	1	8	1
10	42.0	210	30	45	45	5.6	1	8	7
11	38.3	345	30	45	45	4.4	1	8	7
12	42.0	210	30	45	45	5.8	1	8	7
13	37.5	375	30	45	37.5	3.9	1	8	3.5
14	37.5	300	30	45	37.5	3.6	1	7	3.5
16	30.0	60	30	30	30	1.0	1	1	1
17									
18									
20									
21									
22									
23									

Not all participants provided their strength and conditioning data.

Table 25. Summary of other sports session minutes and sRPE per adolescent cricketer (n=17)

Part. number	Other sports minutes					sRPE Other sports			
	Mean per session	Total over 7 weeks	Min per session	Max per session	Median per session	Means	Min	Max	Median
5									
6									
7									
8									
9	60.0	360	60	60	60	7.7	7	8	8
10	60.0	480	60	60	60	6.8	4	9	7
11	65.0	390	60	75	60	7.2	6	8	7
12									
13	75.0	750	60	90	75	6.6	5	8	6
14									
16									
17									
18	60.0	720	60	60	60	6.0	4	8	7
20	60.0	300	60	60	60	7.8	7	8	8
21									
22									
23									

Not all participants provided data about other sessions besides cricket.

Appendix F: Adolescent cricketer-level summary of weekly ACWR ratios

Table 26. ACWR unsmoothed and smoothed ratios per adolescent cricketer (n=17)

Part. number	Week	Day number	ACWR unsmoothed	ACWR Moving averages	ACWR Exponentially weighted
5	W5	28	0.88	0.70	1.11
5	W6	35	0.21	0.31	0.94
5	W7	42	1.69	0.90	0.88
5	W8	49	1.46	1.62	1.00
6	W5	28	0.79	0.92	0.88
6	W6	35	0.15	0.50	0.88
6	W7	42	1.46	0.80	0.88
6	W8	49	1.36	1.24	0.88
7	W5	28	1.03	1.11	0.78
7	W6	35	0.15	0.56	0.78
7	W7	42	1.16	0.59	0.79
7	W8	49	1.26	1.10	0.80
8	W5	28	1.04	1.23	0.71
8	W6	35	0.00	0.41	0.71
8	W7	42	1.25	0.62	0.72
8	W8	49	1.29	1.07	0.73
9	W5	28	0.86	1.16	0.96
9	W6	35	0.17	0.47	0.96
9	W7	42	1.18	0.62	0.96
9	W8	49	1.35	1.14	0.97
10	W5	28	1.18	1.36	0.92
10	W6	35	0.17	0.67	0.92
10	W7	42	0.44	0.37	0.95
10	W8	49	1.66	0.77	0.98
11	W5	28	1.00	1.22	0.81
11	W6	35	0.16	0.61	0.81
11	W7	42	1.30	0.65	0.81
11	W8	49	0.91	0.90	0.82
12	W5	28	1.11	1.35	0.82
12	W6	35	0.00	0.55	0.82
12	W7	42	1.24	0.69	0.82
12	W8	49	1.35	1.08	0.82
13	W5	28	1.17	1.07	0.99

Part. number	Week	Day number	ACWR unsmoothed	ACWR Moving averages	ACWR Exponentially weighted
13	W6	35	0.13	0.67	0.89
13	W7	42	1.14	0.58	0.76
13	W8	49	0.00	0.42	0.72
14	W5	28	1.22	1.56	0.89
14	W6	35	0.00	0.65	0.82
14	W7	42	1.32	0.73	0.73
14	W8	49	1.15	1.16	0.85
16	W5	28	1.14	1.45	0.84
16	W6	35	0.12	0.60	0.81
16	W7	42	1.31	0.76	0.77
16	W8	49	1.30	1.26	0.84
17	W5	28	1.12	1.27	0.82
17	W6	35	0.00	0.47	0.82
17	W7	42	1.33	0.74	0.82
17	W8	49	1.41	1.31	0.82
18	W5	28	1.12	1.36	0.84
18	W6	35	0.27	0.68	0.83
18	W7	42	1.26	0.79	0.80
18	W8	49	1.21	1.21	0.85
20	W5	28	1.26	1.70	0.84
20	W6	35	0.12	0.79	0.83
20	W7	42	1.33	0.77	0.78
20	W8	49	1.27	1.31	0.88
21	W5	28	1.02	1.15	0.91
21	W6	35	0.00	0.46	0.91
21	W7	42	1.36	0.68	0.91
21	W8	49	1.35	1.23	0.91
22	W5	28	1.10	1.31	0.88
22	W6	35	0.00	0.51	0.88
22	W7	42	1.33	0.66	0.88
22	W8	49	1.57	1.49	0.88
23	W5	28	1.10	1.27	0.88
23	W6	35	0.00	0.50	0.88
23	W7	42	1.36	0.70	0.87
23	W8	49	1.19	1.24	0.88

Appendix G: Ethical Clearance Certificate

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R14/49 Mr Nico Grobler

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M220464

NAME: **(Principal Investigator)** Mr Nico Grobler

DEPARTMENT: Physiotherapy [redacted]

PROJECT TITLE: *Match and training intensity in high school cricketers and its association on sports performance: Development of a questionnaire*

DATE CONSIDERED: 29/04/2022

DECISION: Approved unconditionally

CONDITIONS:

SUPERVISOR: Prof Benita Olivier

APPROVED BY: Dr CB Penny, Chairperson, HREC (Medical)

DATE OF APPROVAL: 25/07/2022

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions.Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report.** The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in **April** and will therefore be due in the month of **April** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

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29/04/2022
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