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The Accuracy and Validity of Self-Reported Throwing Loads and the Characteristics of Throws by Elite Cricket Players in Australia

Zachariah G. Hoyne
The University of Notre Dame Australia

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THE ACCURACY AND VALIDITY OF SELF-REPORTED THROWING LOADS AND THE CHARACTERISTICS OF THROWS BY ELITE CRICKET PLAYERS IN AUSTRALIA

Zachariah Gerard Hoyne

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Statement of Original Contribution

To the best of the candidate's knowledge, this thesis contains no material previously published by another person, except where due acknowledgement has been made.

This thesis is the candidate's own work and contains no material which has been accepted for the award of any other degree or diploma in any institution.

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Abstract

Objectives: To determine the relationship between elite cricket player's self-reported and independently observed throwing volume. Examine whether sex, playing position, or time to upload self-reported data post training influences the accuracy of self-reported throwing loads. Describe the type and number of throws performed during elite cricket training, and identify characteristics such as type, distance and accuracy of throws.

Design: Cross-sectional study.

Methods: A total of eight female and 18 male professional cricket players participated in the study. Overarm throws from 12 training sessions during the 2020-21 cricket year were observed. Player self-reported throwing volume data were retrieved post training, with the time difference between session completion and self-reported data upload recorded. Observations on throwing type (warm-up, drill throw), distance (± 30 meters) and accuracy (hit or miss target) of throws was noted. Correlation and agreement was assessed using a Spearman's Rank Correlation Coefficient and a Bland-Altman plot of agreement. Two, Independent-Samples Kruskal-Wallis tests were used to investigate if playing position and sex had an influence on absolute magnitude of error of reporting.

Results: A moderate positive correlation was found between self-reported and observed throwing loads (rho = 0.65), however only 22% of players reported values within a clinically acceptable error of 10%. Players reported a mean absolute magnitude of error of 11.2 (9.8) throws and a mean magnitude of error of 24.8% (SD 16.0%). Sex did not influence reporting accuracy ($p = 0.414$). Playing position had a statistically significant ($p = 0.031$), though not clinically meaningful, relationship. Females uploaded self-reported data the day of training, whereas most males reported the day following. Reporting the day of training, or the day following training did not appear to result in poorer self-reported throwing load accuracy.

Conclusions: The findings of this study question the validity of player self-reported throwing load as most players recorded in excess of 10% error. Sport support staff and players should consider whether the current accuracy of self-reported throwing load justifies its collection and use in the high-performance environment.

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Research Publications

A manuscript with results from this thesis has been submitted to the *Journal of Science and Medicine in Sport* and is currently under review.

Hoyne, Z., Cripps, C., Mosler, A., Joyce, C., Chivers, P., Chipchase, R., Murphy, M. Self-reported throwing volumes are not a valid tool for monitoring throwing loads in elite Australian Cricket players: an observational cohort study.

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Chapter One: Introduction

Cricket is an internationally popular sport with over one billion fans worldwide (Cook & Strike, 2000; International Cricket Council, 2018). At the professional level, cricket is played in three formats: the most recent, Twenty20, in which each team competes for 20 overs; One-Day cricket spanning up to 50 overs per team; and the oldest and most traditional, Test-Match cricket which is played over five days, completing 90 overs per day. Typically, a team consisting of 11 players, has bowlers (medium to fast pace and potentially inclusive of a spin bowler), a wicket-keeper, and batters which may also include “all-rounders” which are able to both bat and bowl. While 11 players are on the field at any one time, a maximum of six substitute fielders must be available before the toss, one of these players, the ‘12th man’ is able to be substituted for an injured player but can only field. This substitute player may not bat nor bowl, unless they are a concussion substitute (International Cricket Council, 2019). From a fielding team perspective, their aim is to stop the batting team from making runs and to take wickets as fast as possible, in particular retrieving the ball from any point on the field.

The rise in popularity of Twenty20 cricket over the last decade has led to a number of player management issues for professional cricket high-performance staff: players who have fewer days of rest, and increases in total cricket exposure over time, leading to increases in total cricket exposure (English, 2011; Warren et al., 2019). Over the course of a match, throwing frequency in fielders can be high, especially those in the infield, leading to high amounts of physical stress on the intrinsic structures of the shoulder and elbow (Bartlett, 2003; Black et al., 2016). Increases in training and competition frequency over the past decade may be one the reasons for an increase in overuse injuries in professional cricket, with total injuries in elite male cricket increasing from 54.6 new injuries per 100 players per year in 2006/07 to a high of 74.2 per 100 players in 2011/12 (Orchard et al., 2016; Petersen, Pyne, Dawson, et al., 2011). Total shoulder injuries account for an estimated 12-17% of all injuries in female and male elite cricket, including shoulder instability, shoulder tendon injuries and other non-described shoulder injuries (Orchard et al., 2016; Warren et al., 2019). To support injury prevention, it is important to identify, and quantify where possible, the risk factors contributing to these injuries. This information will inform and challenge current training trends and potentially reduce injury risk. The Translating Research Into Injury Prevention Practice framework (TRIPP) developed by Finch (2006) is a six step framework which can help research lead to injury prevention implementation in sports. This model proposed that effective injury prevention begin with valid and robust injury surveillance practices. Injury surveillance should also include accurately quantifying athletic exposures to load (Bahr et al., 2020). Quantification of training loads can be self-reported by a player, including but not limited to number of throws performed in drills, and may achieve the goal of quantifying an important injury risk factor.

Measurement of training load is used by professional sporting teams to quantify the risk of injury in players and to develop an acute:chronic workload ratio for the players (Jones et al., 2017; Pote & Christie, 2018). Increasingly, GPS throwing trackers (such as PulseTHROW, Driveline Baseball ©) are used to track number and speed of throws as well as elbow angle at release. Self-report throwing load (the number of throws performed in a training session or during a match) is the current preferred method of quantifying throwing load exposure used by Cricket Australia (CA). To track throwing load, each player must provide their self-reported number of throws performed for a specified day of cricket exposure (training and / or competition). The players enter their self-reported throwing load, in their own time, into an online Cricket Australian software program, Athlete Management System (AMS) (Fair Play Pty Ltd). As the program can be accessed on the individual's mobile devices, it allows for data upload to occur when convenient for the individual. As explored in more detail below, this may lead to issues with data accuracy and various subconscious biases.

Self-reported data can be influenced by *Social Desirable Bias*, where individuals may be inclined to report data which may be favorable to the eyes of coaching staff (Nancarrow & Brace, 2000). Similar to *Social Desirable bias* is the Hawthorne effect, which can change an individual's awareness of actions if they know they are being monitored (Roethlisberger & Dickson, 2003). Furthermore, the accuracy, and hence validity, of this self-reported measure may be influenced by recall bias, where players can forget their number of throws during the session, or forget altogether, especially if data were recorded several hours after training has ended. The time from cessation of training has shown to have an inverse relationship with self-reported data accuracy using other metrics such as rate of perceived exertion (RPE) (e.g. they train at 10 am but record their data at 6 pm that evening) (Fanchini et al., 2016; Scantlebury et al., 2018; Stopher, 2012). Due to this potential of biased reporting, there is a need to ensure the data collected by CA is valid, so that high-performance staff can be confident throwing loads data, used to managed player/ team load prescription and rehabilitation, are valid.

Only one study has been conducted examining the types of throws (distance, accuracy and type) executed during cricket training and competition but minimal detail on the methodology of data collection and analysis was reported (Saw et al., 2011). This study found throw downs, a throw which simulates a bowl to a batters or wicket-keeper, was the most common type of throw during training (Saw et al., 2011). In baseball it has been demonstrated that different types of throws impact shoulder injuries differently, with throws which require more manipulation of the shoulder and elbow (slider, curveball) compared to a normal throw to have the greatest risk of injury, highlighting the need for deeper analysis in throwing sports (Lyman et al., 2002). Throwing technique and type, as well as velocity have been highlighted as indicators for injury risk in throwing sports, with statistical association between max pitch velocity negatively effecting injury in baseball players ($p < 0.05$) (Asker et al., 2018; Bushnell et al., 2010). These factors can be modified in training to help minimise the risk of injury for the players.

Hence there is a need for detailed and accurate information about cricket players throws in training as little is known on the validity of current throwing load data collection. This information is critical as a baseline measure and to program ongoing player assessment and management. In particular ensuring the collection of detailed and accurate throwing information would help coaches and training staff to better individualise training and rehabilitation for each player as well as extend the existing literature on this topic.

1.1 Purpose of Study

The purpose of this study was to evaluate the concurrent validity of the current method of throwing load data collection used within elite, Australia Cricket as well as to describe the number, accuracy, distance and type of throws performed during cricket training.

1.2 Significance of Study

Player load monitoring tools are only useful to high-performance staff if the data obtained is valid. Invalid data used for load monitoring purposes may result in prescription of training loads which either under- or over-stimulate a player, subsequently leading to increased injury risk and/or reduced performance outcomes. This research evaluated the protocols currently used within Australian Cricket to monitor elite players, and provides important empirical evidence to fill a clinical research gap with respect to the use of current throwing load monitoring techniques. Outcomes provide important recommendations for CA in their ongoing elite player throw training load management for both injury prevention and rehabilitation.

1.3 Research Questions

1. Are self-reported throws a (concurrent) valid exposure metric in elite, Australian cricket players? That is, does self-reported throwing load predict the value of observed throwing load
2. What are the characteristics of throws used while at training?
    a. What are the distances thrown in cricket training?
    b. How accurate are throws in cricket training?
3. When do elite cricket players upload their self-reported throwing volumes?
4. Does sex, playing position, or time from training to self-report influence the accuracy of player self-reported throwing load.

1.4 Definitions of Key Words

Cricket Australia (CA)	The governing body of cricket in Australia. Refers to the governing body and the national women's and men's team.
Athlete Management System (AMS)	Online software program used by Cricket Australia to log, track and maintain information on the athletes within the elite national and state programs. Information such as demographic, training load and weekly calendars.
Match session throw	Any overarm throw produced during a match.
Drill throw	Any overarm throw produced during a fielding drill at training.
Throw down	A throw which simulates a bowl to the batters or wicket-keeper.
Throwing accuracy	The ability for an overarm throw to reach its intended target.
Self-reported throws	An individualised self-assessment of the amount of throws performed in a given time.
Training observations	Where an athlete was observed throwing during a cricket training session by a member of the research team. The athlete must have performed at least one overhead throw.
Absolute/Training Load	Amount of 'work' produced by an individual. Can be calculated over day, week or year, usually in arbitrary units (AU).If an athlete performs 10 throws at 75% max effort, (10 throws x .75 (percent) = 7.5 AU. Training load can include internal factors such as nutrition, sleep and genetics.
Acute:Chronic Workload Ratio	An estimate of an athlete's 'fitness' and 'fatigue'. Calculated by the Acute (7 day rolling average) and Chronic (One month) workload.

Chapter Two: Literature Review

2.1 Overview of Cricket

Cricket is a team sport comprised of 12 players competing to score the most runs for a given time. Cricket is played in three forms, Twenty20, One-day and Test match. A team comprises of fast bowlers, usually bowling at speeds between 120 – 160kph (75 – 100mph) (Orchard et al., 2015b), spin bowlers, batters and a wicket-keeper. Bowlers may still bat, however they are typically lower in the batting order. While not bowling they field the ball, usually in the outfield. Batters very rarely bowl, their role on the team is to score runs and field, mainly in the infield. The wicket-keeper, who is a specialist position, fields behind the stumps. They are in an optimal position to catch the ball from behind a batter. The wicket-keeper does not bowl and therefore are typically skilled at batting. A cricket team will also have a handful of all-rounders, who can bat and bowl.

While a team is bowling, all team members are required to field. Depending on the form of cricket being played, and whether or not a powerplay (fielding restriction) is being enforced, a restricted number of players may be in the outfield (International Cricket Council, 2019). The role of a fielder is to stop the batters from scoring runs by collecting and throwing the ball back to either the wicket-keeper or bowler before the batter runs between the wickets. The fielder should also attempt to stop the ball from passing over the boundary to stop four or six runs from being scored. A fielder can get a batter out by; catching the ball while in the air or by throwing the ball into the wickets before the batter has returned behind their crease.

2.2 Cricket Participation and Popularity in Australia

Cricket is a very popular summer sport played and watched by more than one billion fans worldwide (International Cricket Council, 2018). During the playing season of 2019-20, CA community engagement saw over 2 million visitors to the cricket.com.au website and app each month between November 2019 through January 2020 (Cricket Australia, 2020). Cricket Australia also reached 113 million unique Facebook visitors from October 2019 through

February 2020. Cricket in Australia has seen increases in participation over the last half decade, with over 700,000 unique registered participation, up 3.8% (Cricket Australia, 2020). Female participation has increased by almost 15% to 76,400 participants, Aboriginal and Torres Strait Islander people (+6.4%), people form multicultural backgrounds (+9.2%) and people with disabilities (+5.1%) all showed growth in the last five years. All senior participation metrics had strong growth with increases in club cricket (+4.7%) and non-club competitions (+29%). Elite cricket has also increased in attendance and viewing, with over 500,000 test cricket attendees, an average of 191 thousand views per women's Big Bash League match, and the Men's Big Bash League being the top rated sports league and second highest attended sports league in Australia (Cricket Australia, 2020).

2.3 Physical Demands of Cricket Fielding

Cricket is a demanding game, with players having to spend hours in the field being mentally prepared to collect the ball. The position of the fielder greatly influences the physical demands placed on the player. Although fielding positions are not set, general positions are adopted by most teams. Overall, cricket fielders are required to perform three basic tasks; running, throwing and catching (Petersen, Pyne, Dawson, et al., 2011). For men, the International Cricket Council (2019) state the boundary shall be no longer than 82.29 meters (90 yards) and no closer than 59.43 meters (65 yards). For women, the boundary shall be no longer than 64 meters (70 yards) and no closer than 54.86 meters (60 yards) (International Cricket Council, 2020).

2.3.1 Fitness Demands

Due to game demands requiring cricket players to field for hours at a time, and fielding events being sparsely spread during play, there is consensus that cricketers require superior aerobic fitness compared to some other team sports (MacDonald et al., 2013; MacDonald Wells et al., 2018; Vickery et al., 2018). When looking at GPS analysis of cricket competition, differences are seen depending on the form of cricket being played. In Twenty20 cricket, higher distances are covered at all speeds; walking (0 – 2.0m/s), jogging (2.0 – 3.5m/s), running (3.5 – 4.0m/s), striding (4.5 – 5.0m/s), sprinting (≥5m/s) and total distance compared to One-day and Test cricket (Petersen et al., 2009; Petersen, Pyne, Portus, et al., 2011).

2.3.2 Throwing

Throwing in cricket, much like other overhead sports such as tee ball and baseball, require a player to produce great amounts of force and torque through their upper limbs to project the ball from the field back to a teammate (Cook & Strike, 2000). The act of throwing is a five-phase movement beginning with; preparation phase, arm acceleration, ball release, arm deceleration and follow-through (Cronin et al., 2016; Dutton et al., 2020). Previous research has shown sex and competition level have significant impact on peak throwing velocity ($p < .001$), as well as training volume having a significant effect ($p \leq .001$) on elite and sub-elite peak and mean maximal throwing velocity (Oz et al., 2016). There is also an observed speed-accuracy trade-off with cricket throwing. Improved accuracy is observed at 75-85% of maximal velocity compared to 50% and 100%, and accuracy decreases for throws from further than 40 meters (Cook & Strike, 2000; Oz et al., 2016). One previous study has examined throws completed in training and competition, in which over 2,100 sessions of elite male cricket and more than 42,000 throws were observed via video analysis (Saw et al., 2011). Match session throw volume (mean throws for squad 10.48 SD = 10.39) was much less than match warm-up (M = 27.07 SD = 19.24), drill (M = 42.48 SD = 26.28) and Throw Down (M = 66.52 SD = 40.00) (Saw et al., 2011).

2.3.3 Catching

Catching is an integral skill of cricket and is regarded by some to be the most mentally demanding part of the game (Scott et al., 2000). Placement of a fielder has great effect on the parameters of catching, with infielders needing fast reaction times and superior judgmental skills in order to catch a ball behind the wickets at great speeds, to outfielders who may have to travel at high speeds in order to reach a hit into the outfield (Bartlett, 2003). Although during competition bowlers and the wicket-keeper are the most active members on the field, displaying 32% and 12% of all fielding events, fielders play a stronger role with catching (MacDonald Wells et al., 2018). One study, which has investigated catching numbers in competition, over 16 innings of the 2011 One-day International (ODI) Men's World Cup, saw a total of 42 catches (MacDonald Wells et al., 2018). This was spread over close fielders (13 catches), inner fielders (18 catches) and outer fielders (11 catches). In comparison, it has been documented that demands and stimulus produced in training exceeds the stimulus faced in competition (Petersen, Pyne, Dawson, et al., 2011; Vickery et al., 2018). Although no specific number of catches are reported, duration of fielding drills in an average male Australian Academy cricket session include; fielding skills sessions (49 minutes), crouched catches (4 minutes) and high catches (17 minutes) (Petersen, Pyne, Dawson, et al., 2011).

As cricket is a physically demanding sport, it is important that the players are able to perform the required movements in a safe manner in order to perform at their best without being injured (Pardiwala et al., 2018). Injury to athletes can be detrimental to their career, and common sites for injuries must be highlighted to ensure the risk of injury is minimised while running throwing and catching in cricket.

2.4 Injury Sites Commonly Seen in Cricket

As cricket is multifaceted (incorporating running, batting, bowling, throwing and catching) there are a range of injury regions reported in players. Lower limb injuries are very common in cricket, representing almost half of all injuries (Orchard et al., 2016; Stretch, 2003; Warren et al., 2019). Hamstring injuries tend to be the most common injury of the lower limb, mainly attributed to running events. Hamstring injuries are often due to running in with fast bowlers, batters running between the wickets and fielders running to stop a ball. Hamstring injuries represent 17% of all lower limb injuries and were the most common injury for elite senior male cricketers from 2007/08 to 2016 (Orchard et al., 2016; Stretch, 2003). Lumbar spine injuries are also prevalent in cricket fast bowlers, due to the high amount of torque produced during the bowling action and follow through (Pardiwala et al., 2018). Lumbar spine injuries represent over 11% of all injuries for female cricketers and between 21% to 65% in young men and can lead to severe disc degeneration (Arora et al., 2014; Warren et al., 2019). Injuries to the shoulder and elbow are the most common injury while fielding, with players landing awkwardly or injuries related to throwing being the most common mechanism of injury (Pardiwala et al., 2018).

2.5 Injury Risk in Throwing Dominant Sports

Injury risk is multifaceted as there are many fixed and modifiable factors which play a role in influencing a player's predisposition to injury and/or ability to increase or decrease injury risk (Asker et al., 2018; Eckard et al., 2018). Fixed factors including age, sex, injury history and an individual's biomechanics are largely unmodifiable. On the other hand, modifiable factors can be altered and are the key characteristics measured by high-performance staff, with training loads a critical consideration. Below are factors which have shown to increase the risk of injury in throwing athletes, such as but not limited to cricket and baseball.

Figure 1

Risk Factors for Throwing Injuries (Asker et al., 2018)

[redacted]

2.5.1 Fixed Factors

Age

Previous research has shown an association between age and sports injury risk (Enger et al., 2019). Factors including sports participation and body development play a role in the risk of sports injuries (McQuillan & Campbell, 2006; Sytema et al., 2010). Cricket players aged below 20 years old demonstrate the highest proportion of injuries (36%) with almost half of those injuries being head injuries (48.5%) (Walker et al., 2010). Peaks in hospitalisation due to sports injuries are seen in adolescents in populations from Norway, Netherlands and the United Kingdom, with shoulder injuries highest in ages 10-15 years (Enger et al., 2019; McQuillan & Campbell, 2006; Sytema et al., 2010). This increased risk in upper extremity sports injuries may be seen due to young adolescents going through physical and physiological changes which may place greater stress on the body (Adirim & Cheng, 2003). Developmental changes such as growing cartilage and susceptibility of growth plates place adolescents at an increased risk of injury or irregular development which can lead to increased injury risk in the future adulthood. Adolescents also tend to display improper technique which may lead to increased injury risk (Faigenbaum & Myer, 2012). Improper technique will be discussed more below.

Sex

Sex differences, similar to age, play a role in injury risk as anatomical and risk-taking behaviours are different between sexes. Males tend to be at higher risk of all sport injuries at all ages than women (McQuillan & Campbell, 2006; Owens et al., 2009). A study on shoulder injuries in collegiate athletes from the National Collegiate Athletic Association (NCAA) from 1989-2004, found male athletes were more likely to sustain any shoulder injury than females (incidence rate ratio [IRR], 3.50; 95% CI, 3.29-3.73) as well as from player contact (IRR, 2.74; 95% CI, 2.31-3.25) (Owens et al., 2009). However, female cricket players tend to have a higher proportion of shoulder injuries than any other injury (12.4%) which is typically lower in males (peak of 2% in 2001-02) (Orchard et al., 2006; Warren et al., 2019).

Previous Injury History

Previous injury has been shown to greatly increase the risk of future injury in all athletic populations (Asker et al., 2018; Fulton et al., 2014). Limited research into previous injury history in cricket has been performed. Orchard et al., (2015a) showed in male elite cricket fast-bowlers, all bone stress injuries were almost twice as common if the player had suffered an injury in the same season (Risk ratio RR = 1.71; 95%CI 1.25 – 2.34, p =.001). In other sports, youth baseballers were three times more likely to be injured in the future if they had sustained an injury at all in the past (RR = 3.34; 95% CI = 2.16–5.17, p = <.01) (Matsuura et al., 2017).

Biomechanics

Research investigating the biomechanics of baseball pitchers have shown increased injury risk with those who had insufficient external rotation (<5º greater external rotation in the throwing shoulder) being twice as likely to be placed on the disabled list for a shoulder injury (RR = 2.2; 95% CI = 1.2-4.1, p = .014) and four times more likely to require shoulder surgery (RR = 4.0; 95% CI = 1.5-12.6, p = .009) (Wilk et al., 2015). Due to the similarities in throwing technique, it can be inferred that similar results my become apparent in cricket players. Although not significant, shoulder internal rotation deficit (RR = 0.6; 95% CI = 0.2-1.5, p = 0.23), total rotation deficit (RR = 1.5; 95% CI = 0.8 – 2.8, p = 0.21) and flexion deficit (RR = 0.6; 95% CI = 0.2-1.4, p = 0.20) may have contributed to increased shoulder injury risk in these baseball players (Wilk et al., 2015). New research has also identified increases in shoulder injury risk in female cricketer players with internal-external dominant shoulder strength ratio exceeding 1.0 were almost twice as likely to suffer a shoulder injury (RR = 1.84; 95% CI = 1.16 – 2.93, p = .01) (Murphy et al., 2020). Other internal biomechanical factors play a part in the velocity and technique of throwing.

Variations in the velocity of a throw can alter the stress placed on an athlete's upper limb musculature and tendons (Cronin et al., 2016). To date, no field-based assessment of throwing velocities and upper limb injury in cricket has been performed as it is difficult to obtain useful data (Freeston et al., 2007; Petersen et al., 2011). Difficulty in the assessment of throwing velocity is a contributor to lack of regular velocity monitoring in field-based cricket training. Reliably measuring velocity variables requires speed radar guns to be placed directly in line with the ball trajectory which for field throws is largely unattainable (Freeston et al., 2007). However, throwing velocity in baseball has been shown to increase the risk of injury. Injured pitchers have higher average pitch velocities (89.22 ± 5.36 vs 85.22 ± 3.24 mph) compared to uninjured players, and faster pitch velocities significantly increase elbow injury rate ($p = .04$) (Bushnell, Anz, Noonan, Torry, & Hawkins, 2010). Similar findings have been seen in adolescent baseball players with injured players demonstrating higher velocity throwing (Popchak et al., 2015).

Throwing type and technique can influence injury risk in throwing athletes. Similar to throwing velocity, manipulation of the throwing execution can change the impact of torque of the glenohumeral head and place strain on the surrounding musculature (Asker et al., 2018). To date, no assessment of throwing styles and injury has taken place in cricket, which may be due to the difficulty of performing objective measurement of throwing variation during training and competition. However, this data is highly relevant to cricket throwing loads as many different throws for cricket exist such as throw downs, throwing at the wicket for a run out, and throwing to return the ball to the wicket-keeper from either the infield or outfield. Lyman, Fleisig, Andrews, & Osinski (2002) investigated baseball pitching type and number of pitches over a season and found throwing curveballs (a pitch which dips down towards the ground) significantly increases shoulder injuries ($RR = 1.52$, $p = .04$). Furthermore, sliders, (a pitch that moves laterally away from a batter) have also demonstrated significant injury risk to the adolescent baseballer's shoulder ($RR = 1.77$, $p = 0.38$) and elbow ($RR = 1.86$, $p = .03$).

2.5.2 Modifiable Factors

Participation Setting

Shoulder injury risk is higher in competition than in training (Dick et al., 2007; Orchard et al., 2016). Only observational analysis of throwing has been performed comparing training and competition in cricket, with no injury studies examining differences between training and competition (Petersen, Pyne, Dawson, et al., 2011). However, in other sports, injury risk for male baseballers was three times higher in a competition setting than in practice (5.78 versus 1.85 injuries per 1000 athlete-exposures (AE), RR = 3.1; 95% CI = 3.0-3.3, p <.01) and women's volleyball had higher competition versus training injury risk (4.58 versus 4.10 injuries per 1000 AE, RR = 1.1; 95% CI = 1.0-1.2, p <.01) (Agel et al., 2007; Dick et al., 2007).

Playing Position

Playing position is also a factor for injury in cricket, as fast bowlers consistently report much higher rates of total injuries compared to batsman, wicket-keepers and spin bowlers (Orchard et al., 2016; Ranson & Gregory, 2008; Stretch, 2003). For shoulder specific injuries, of the 158 elite male cricket players surveyed, the playing position with the highest percentage of shoulder injuries were specialist batters (33.3%), followed by spin bowlers (22.2%) then fast bowlers (21.4%). No wicket-keepers sustained a shoulder injury in this investigation (Ranson & Gregory, 2008).

Training Load

Current research shows a protective effect of moderate absolute loads and moderate relative changes in load for team sport populations, which is the premise for recording and monitoring load in athletes (Eckard et al., 2018). Throwing athletes perform tens-of-thousands of throws in a competition year with cricket and baseball players throwing on average 42,000 and 100,000 times respectively (Karakolis, Bhan, & Crotin, 2013; Saw et al., 2011). In cricket, research has quantified the number of throws performed during competition (M = 10.48, SD =

10.39), pre-match warm-up (M = 27.07, SD = 19.24), drill (throws occurring in fielding drills at training) (M = 42.48, SD = 26.28) and throw-down (throws which simulate a bowl to a batsman or wicket-keeper) (M = 66.52, SD = 40.00) (Saw et al., 2011). As stated by Saw et al. (2011) a limitation of the study was that the research team was unable to account for throwing metrics from grade cricket as it was not feasible with the resources available to travel to several grade team trainings. This study reported a significantly increased risk ratio for throwing more than 75 throws per week (RR = 1.73; 95% CI = 1.03 - 2.29, p = .004) (Saw et al., 2011). On average, injured players reported throwing more per week (injured M = 112.09, SD = 35.65, uninjured M = 72.81, SD = 26.05, p = .004) and more throws per day (injured M = 50.57, SD = 12.92, uninjured M = 38.00, SD = 15.06, p = 0.061) compared to uninjured players. The injured players also threw more in the week leading up to injury, throwing 38.91 more throws and with 2.19 less rest days in between throwing sessions. The study by Saw et al., (2011) was the first to investigate throwing loads in cricket. Further research is required to understand not just how load is correlated to injury in cricket, but also the reliability and validity of the measures used by high-performance staff to monitor throwing loads.

2.6 Monitoring Throwing Load

Monitoring of external throwing loads is critical to ensure appropriate throwing volumes are applied to the players to enhance performance and minimise injury risk. The use of valid outcome measures is an essential part of applying the TRIPP framework (Finch, 2006). This framework, was developed to ensure optimal implementation of efficacious injury preventative practices. There are a number of available tools which can support high-performance staff to effectively monitor training loads. When considering which tools should be used, assessment of the appropriateness of the tool, as well as consideration of the usability and validity of the tool must be considered to ensure reliability of results (Jones et al., 2017). It is also important that the measures minimise the burden on the players involved to ensure the players are not distracted during performance (Murphy et al., 2021).

2.6.1 Video Analysis

Video analysis, in conjunction with observational load monitoring, is commonly used in professional sport during competition. Video analysis incorporates the video capture, storage and coding (transforming) of data points onto the video stream (Jayal, McRobert, Oatley, & O'Donoghue, 2018).

However, video analysis is a very labour intensive methodology requiring time to record, store, and transfer all footage, with many professional sports teams requiring all matches and training session to be transcoded, with many camera angles (streams) being used (Jayal et al., 2018). The coding of training sessions poses the greatest difficulties as players may be spread out and performing multiple drills simultaneously. It is for this reason that video analysis in training sessions is sparsely used to record time-motion descriptors in conjunction with other metrics such as GPS units (Petersen et al., 2011).

2.6.2 Observational Analysis

A second frequently used throwing load monitoring technique is observational analysis which often uses throw/bowling diary from a staff member or online databank (Black et al., 2016). Generally, staff members from the team or external statisticians will observe and measure throwing load during training and/or during competition.

This form of load assessment, has much fewer time requirements, as less manipulation of the data is needed. Best practice of observational load monitoring is supported with video analysis to make sure no false-positives are present, however, with time and resource constraints this collaboration is not always implemented (Black et al., 2016; Jayal et al., 2018; Saw et al., 2011). In cricket, observation monitoring of throwing load is difficult in training as at any point more than 25 players may be present. Using only a handful of staff to record the number of throws for such a large group can lead to issues of validity with possible decrease in quality and depth of information gathered (Black et al., 2016; Jayal et al., 2018). Additionally, in a field-based setting, it is difficult to obtain objective measures of throwing accuracy, velocity and distance which all play a role in the influence of throwing volume and training load (Black et al., 2016).

2.6.3 Self-Reporting

Player self-reporting is used in many different data analysis situations in non-sport environments as well as cricket and other sports (Chasimpha et al., 2020; Gonyea, 2005; Phibbs et al., 2017; Saw et al., 2015; Saw et al., 2011). Typically used to report on intrinsic metrics (rate of perceived exertion, mental wellbeing etc.) self-reporting allows for insight into the behaviours and feelings of the players, and a measure of player internal load (Fanchini et al., 2016; Nikolaidis & Knechtle, 2020; Saw et al., 2016).

Social Desirable Bias

As with any form of measure, self-reported data is not without fault (Tullis & Albert, 2013). The term “Social Desirable Bias” reported by Nancarrow and Brace (2000), outlines the possible reporting of externally desirable measures which may be favourable in the eyes of the data collectors. For example, a player who has thrown 60 throws in a training session would know that this is beyond what the allocated throwing loads were, so instead they may enter 45 throws into the database, which would impact the validity of the metric (Nancarrow & Brace, 2000).

Hawthorne Effect

The Harthorne effect, similar to social desirable bias, can result in a heightened awareness of one’s actions, therefore influencing an individual’s ability to *recall* information (Roethlisberger & Dickson, 2003). This may influence a cricket player to focus more on reporting more accurately than would normally happen on any given day. If the players know they are being studied, they might pay more attention to the number of times they threw than under a normal recording situation (McCambridge et al., 2014; Roethlisberger & Dickson, 2003).

Recall / Memory Bias

The validity of the metric can also be influenced by players forgetting the number over the course of the training session, which over a two-hour period is likely, especially if the players have to record other variables concurrently and do not record the data for some hours after training (e.g. they train at 10am but record their data at 6pm that evening). This, *recall* or *memory bias*, explains an inverse relationship between data accuracy and time of recall (Abdalla et al., 2015; Aylesworth & Kuo, 2018; Cherpitel et al., 2018; Stopher, 2012). Although the presence of recall bias has not been formally investigated in cricket, it is clear through the availability of research in other fields that recall bias has a negative effect on the outcome of data provided after an event (Fanchini et al., 2016; Scantlebury et al., 2018).

The self-reported number of throws metric used by CA has only been assessed for its validity once by Saw et al. (2011). However, a limitation to this study was players were aware of the study being conducted, potentially inappropriately elevating the player's awareness of session throw counts, beyond that which may be typical for a standard training session (McCambridge et al., 2014). Further validation of this monitoring tool is needed to confirm the findings from Saw et al. (2011) which demonstrated a correlation co-efficient of 0.99, with a mean error of 1 throw (SD = 2). If a player reported biased information, the subsequent training load measures and other data which has derived from this inaccurate information will not be a true representation of that player's throwing load count. It is essential that load monitoring information collected is both valid and reliable to ensure the subsequent training prescriptions are appropriate to support performance outcomes and minimise injury risk (Murphy et al., 2021).

Chapter Three: Methodology

3.1 Participants & Experimental Design

This cross-sectional study aimed to primarily investigate the concurrent validity of cricket player's self-reported number of throws and its agreement with actual observed throwing numbers. Eighteen male, mean (SD) age = 25.9 (4.5) years, weight = 86.0 (8.4) kgs, height = 188.3 (6.3) cm and eight female, age = 24.6 (3.7) years, weight = 64.9 (6.5) kgs, height = 168 (5.9) cm contracted elite players from the West Australian Cricket Association (WACA) were recruited to the study. Inclusion criteria were that players had to complete at least one training observation throughout the data collection period. As a result, one player was excluded from the study due to injury. Data collection occurred during pre-determined in-season training sessions at the WACA and Murdoch University Playing Fields. Training observations were competed from November 2020 through February 2021.

Ethical approval was provided by the University of Notre Dame Australia Human Research Ethics Committee (Approval Number: 2020-114F). As players were required to be blinded to the purposes of the study to avoid influencing results, a waiver of consent was approved for data collection. However, the players were made aware of the research study after data was collected and were given an opt-out form. None of the players chose to opt out from the research study.

3.1.1 Data Collection

Anthropometric (age, height, weight) and player characteristics data including, playing position (fast bowler, spin bowler, all-rounder, batter, wicket-keeper), were provided by the Cricket Australia athlete management system (AMS) (Fair Play Pty Ltd) prior to training observations. Throwing and fielding training took place twice per week for a duration of 2.5 hours. Four post-graduate sports science student observers attended each training session and monitored throwing load of the selected players. Pilot testing on a small sample of players (n = 5) was conducted to ensure reliability between all four observers ($ICC_{3,1}$ = .988, 95%CI .957-.996, $p <.001$). Player selection was randomised for each session ensuring eight players were being recorded. The observer's hand-notated the number of overarm throws and description of each throw for the duration of each training session. Only over-arm throws during the training session were recorded, as this is what the players are instructed to report in the AMS. If the ball release occurred below the shoulder, the throw was not recorded. Similarly, any throw which mimicked a bowling action was not recorded. Description of throw included the accuracy (hit or missed another player, target or wickets), distance (>30 meters, <30 meters) and throw type, assessed as a throw down (a throw which simulates a bowl to a batsman or wicket-keeper), a drill throw (a throw which occurs during a fielding specific drill) or a warm-up throw (a throw before a training session has officially started, which is used to warm-up the player). The accuracy of a throw was measured using modified criteria from Woods, Raynor, Bruce, and McDonald (2015) for Australian football, with an accurate throw one in which the ball hits the wickets or is received by another player either without having to move or only moving one foot. An inaccurate throw was reported if the ball missed the wickets or recipient, or required the recipient of the throw to move both feet to receive the ball. Throwing distance classification was measured on whether the throw was greater than or less than 30 meters long, which simulates a throw from either the infield or outfield on most cricket fields (International Cricket Council, 2019). The time of completion of training and date of session was noted to inform analysis for time between session completion and data entry.

Once training had finished, observers collated their data and waited for player's self-reported data to be input into the AMS data bank (available within 48 hours). Once self-reported data was uploaded, timestamp information was calculated within AMS to determine the time between training session completion and data upload. As observers recorded the throwing volume in real time, prior to player input, the research team was blinded to the player self-reported number of throws. Furthermore, the players were unaware their throwing loads were being externally recorded and therefore blinded to this data prior to entering their self-reported throwing data.

3.1.2 Data Analysis

Anthropometric data, observed throws, player self-reported throws, difference, throwing type, throwing distance and throwing accuracy data collected by hand notation were entered into Microsoft Excel v16.52 (2021). Anthropometric data and playing position were described using count (total), mean (M) and standard deviation (SD). All observed data was described using mean (M), standard deviation (SD), median (Md) and inter-quartile range (IQR). The difference calculated between observed and player self-reported data was calculated and had two outcomes:

1) the magnitude of error and for overall direction of error, raw differences between observed and self-reported data were used which described the variability of player reporting, calculated by subtracting the number of self-reported throws from the number of observed throws, and
2) Absolute magnitude of error, which describes the trend of total difference of reporting, all observed, and self-report differences (values were converted to a positive value so as to describe the deviation from the mean).

The difference between the date of session completion and date of data upload were calculated and presented as M, SD and range (minimum to maximum). These data were not assessed statistically as only three players reported after two days so analysis would be underpowered. The M, SD, Md and IQR were calculated for the total observed and self-reported throws for the entire group and by sex (female / male).

3.1.3 Statistical Analysis

The *a priori* sample size for the study determined a sample of 13 based on a hypothesised moderate positive correlation between player self-reported and observed throws ($r > 0.7$) and with $\alpha = 0.05$ and $\beta = 0.20$ using the calculation (Total sample size = $n = [(Z_\alpha+Z_\beta)/C]^2 + 3 = 13$) (Hulley et al., 2013). Statistical analysis was conducted in IBM SPSS v26.0 (SPSS, Chicago, IL). Self-reported and observed throwing data was assessed for normality using Shapiro-Wilk test with data determined to not be normally distributed, hence the non-parametric tests were undertaken. A Spearman's Rank Correlation Coefficient assessed correlation between observed and self-reported throws, with acceptable correlation set at 0.7 (determined from previous research (Saw et al., 2011)). Correlation was calculated from each player's first recorded session (n = 26). Statistical significance was set to p <.05. A Bland-Altman plot of 95% confidence interval (CI) limits of agreement was performed using MedCalc® Version 19.6, (2020) by comparing each players first recorded session actual throw and self-reported throw (Bland & Altman, 2010). Based off other research on player self-reported load, an agreement limit of 10% error was accepted as a level of satisfactory accuracy for player self-reported data (Giavarina, 2015; Phibbs et al., 2017; Saw et al., 2016).

Two, Independent-Samples Kruskal-Wallis calculations with pairwise comparisons were performed to investigate if independent variables of playing position and sex had an influence on a dependant (absolute error of reporting) variable. A Pairwise comparison was conducted to observe the simple effects within playing position (bowler, batter, wicket-keeper and all-rounder) and sex (female, male) and its influence on the error of reporting.

Chapter Four: Results

Descriptive information on the self-reported and observed number of throws are shown in Table 1. Male players were observed to throw more in total, more accurately, and threw more long throws than females. A total of 1049 throws were observed during training, while 970 throws were self-reported. Males were observed throwing 741 times (mean (SD) throws/session = 49 (15)) while females were observed throwing 308 times (mean (SD) throws/session = 39 (18)).

Players who self-reported throwing volume the day of training (n = 12) had a mean relative error of 23.88% (SD = 20.02), compared to those who self-reported the following day (n = 8) with a mean relative error of 19.78% (SD = 18.83) and those who self-reported more than one day post training (n = 3) with mean relative error of 35.64% (SD = 13.50). Females tended to upload throwing load data to the AMS the same day as training (Md = 0 Range = 0-3 days where 0 represents data being uploaded the day of training). However, males tended to upload throwing load data to the AMS the day following training (Md = 1, Range = 0-13 days). Three players failed to report data upload and were excluded from this analysis.

A moderate positive correlation was reported between observed and self-reported throwing volume (n = 26, Spearman's rho = 0.65, p <.001) (Figure 2). Overall, all players reported a mean absolute magnitude of error of 11.17 throws (SD = 9.77) from what was observed and a mean magnitude of error of 24.76% (SD = 16.04). Figure 3 depicts the Bland-Altman plot examining whether the observed and self-reported throws were similar. Only five (22%) players reported values within an acceptable 10% degree of error (between green lines on Figure 3), with eight (35%) players over-reporting and 10 (43%) players under-reporting.

Table 1

Descriptive Statistics of Observed and Self-Reported Throws by Sex

	Warm-Up		Drill		Accurate		Inaccurate		Short		Long		Observed		Self-reported		Observed VS Reported (Absolute Magnitude of Error)	
	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
Mean	7.13	25.9	31.60	28.79	22.19	42.18	12.98	6.76	28.92	33.11	6.25	15.82	38.50	49.34	32.50	47.33	12.25	9.53
Standard Deviation	4.09	4.07	19.08	9.79	14.95	12.02	6.82	6.07	19.93	10.82	4.44	11.75	17.91	15.29	8.86	15.68	12.44	6.29
Median	8.00	27.00	25.50	31.50	21.00	43.00	9.00	1.17	22.50	33.00	7.25	13.00	32.50	51.00	32.50	45.00	8.50	11.00
IQR	3.88	3.83	16.13	13.63	5.88	14.83	7.13	8.33	14.13	14.67	7.13	14.33	14.75	23.50	15.00	20.00	8.00	9.00

Figure 3

Correlation of Player Self-Reported and Observed Throws

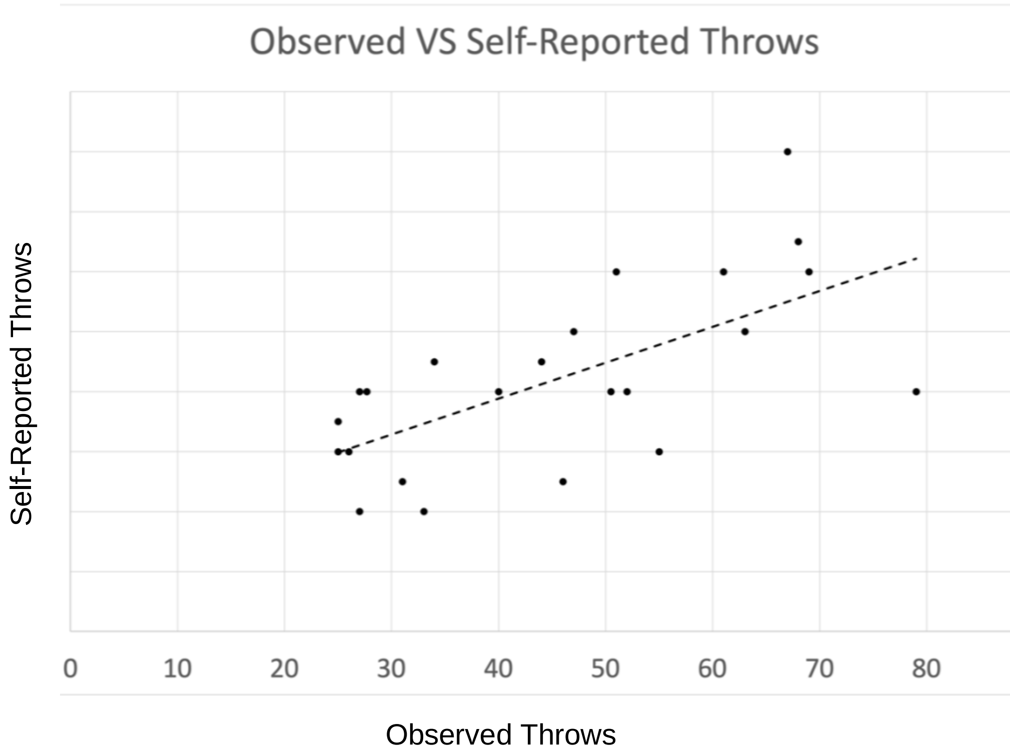
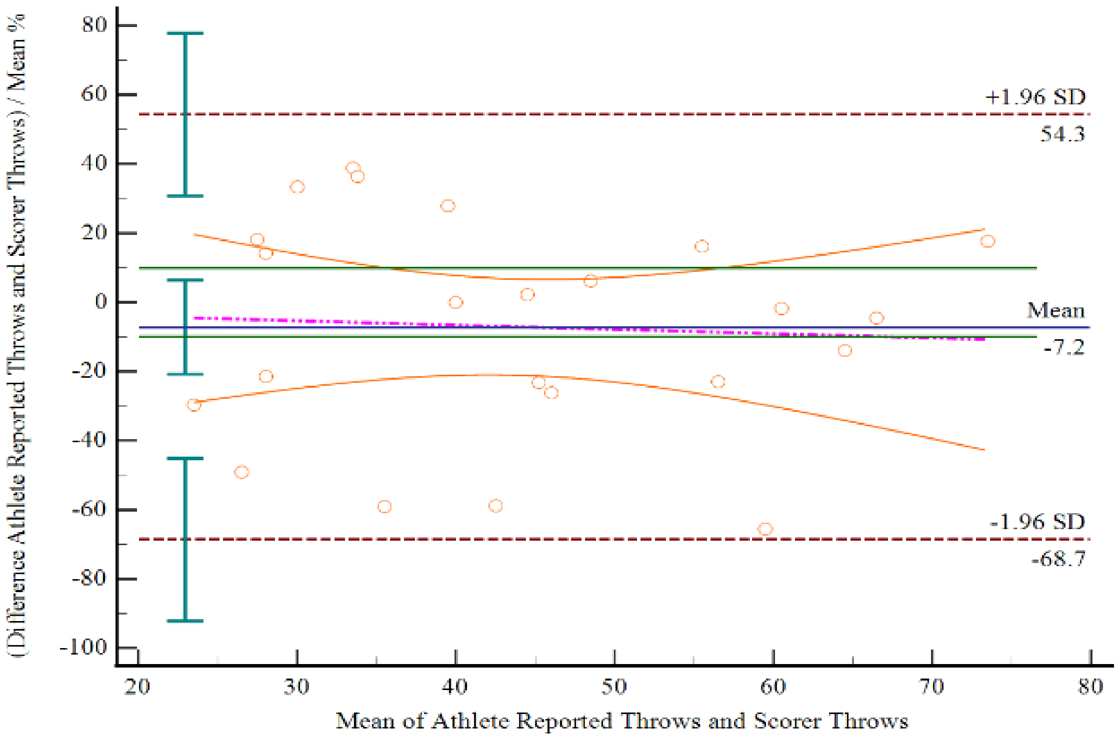


Figure 2

Differences vs Mean of Observed and Self-Reported Throwing Loads



The independent-samples Kruskal-Wallis test investigating sex did not detect a main effect on self-reporting accuracy ($p = 0.414$). The independent-samples Kruskal-Wallis test investigating playing position reported a statistically significant main effect between playing position and absolute magnitude error of reporting ($p = .031$). Pairwise comparison did not find any statistically significant difference in self-reporting accuracy within groups (Table 2).

Table 2

Pairwise Comparisons of Position

Position1-Position2	Test statistic	Standard Error	P-Value
Wicket-keeper – Batter	3.964	5.171	1.000
Wicket-keeper – Bowler	8.188	5.099	0.650
Wicket-keeper – All-rounder	13.250	5.396	0.084
Batter – Bowler	-4.223	3.338	1.000
Batter – All-rounder	9.286	3.776	0.084

Chapter Five: Discussion and Conclusion

This study aimed to investigate the validity of player self-reported throwing loads in elite cricket players. Although player self-report data has a significant and moderate positive correlation, clinically meaningful deviations from actual throwing load were observed (mean percentage error = 24.76%). In addition, cricket players tended to report their findings one day post training with men taking slightly longer than women to report their data. Overall, these findings show that the use of player self-report throwing loads provides an estimate of throwing volume, but it is unlikely to be accurate enough to make it a valid or valuable metric for monitoring throwing loads for injury prevention and rehabilitation purposes.

Our findings are in contrast to those previously reported where a near perfect correlation was found between self-reported and observed throws (Saw et al., 2011). The accuracy reported by Saw et al, (2011) may be linked to social phenomena such as the *Social Desirable Bias* and the *Hawthorne Effect,* as participants in this study were not blinded to the study being conducted. In the current study a moderate, positive correlation between observed and player self-reported data was also found, however further analysis was performed on agreement using a Bland-Altman plot (Bland & Altman, 2010). The plot highlighted that few players accurately self-report throwing loads with only 22% of players reported within the acceptable 10% margin of error. These findings question whether self-reporting of throwing load is a valid metric of load monitoring due to the small agreement observed. Other methods of measuring load (such as GPS packs, video analysis etc.) are more accurate and objective which suggests that further research is needed to identify why self-report is not as accurate in a 'real-world' environment.

In regard to the classification of throwing type, differences in training session execution are seen. This research is also the first of its kind to characterise throws performed in cricket training for female players. Female players threw substantially less warm-up throws compared to male players, with greater emphasis on dynamic and progressively increased movement patterns (lane running, explosive jumping, change of direction) in female warm-ups compared to partner throwing being the main activity in male warm-ups. This could possibly be linked to the time-restraints for female players, with a possible need to prioritise a generalised whole-body warm-up compared to specific warm-ups (Laura, 2021). The throws observed for males in the current study were similar to those seen in participants from Saw et al, (2011) with similar mean warm-up throws (M = 28.79 SD = 4.07 vs M = 27.07 SD = 19.24 respectively). This is likely due to both participant groups following similar training guidelines provided by Cricket Australia and that the research from Saw et al, (2011) being the only research outlining throwing specific recommendations for cricket training.

Similar volumes of mean drill throws were observed between female and male players in the current study. However, these volumes were lower than other research investigating throwing count and injury. These cricket and baseball studies reported higher average throws per session, with higher throwing rates associated with higher injury risk. There is evidence to suggest that cricketers who threw more than 40 times per day may lead to an increased risk of injury (RR = 1.41, 95% CI = 0.88 - 2.26) (Saw et al., 2011). This is much less than observed in baseball with those players who threw more than 75 pitches per session having a threefold increase in injury risk (Lyman et al., 2001). This could be due to players throwing greater distances per throw in training compared to a pitcher throwing from the mound to a batter or catcher.

In relation to time difference from training completion to data upload, Australian Cricket players tended to self-report throwing loads the night of, or the day following training consistent with findings from Saw et al., (2015). Behavioural and injury questionnaires are often affected by recall bias, with an inverse relationship found between data accuracy and time from cessation of training (Aylesworth & Kuo, 2018; Stopher, 2012). Although this is the first study to explore the influence of recall bias in player-reported throwing loads in cricket, our findings differ to work in other sports whereby other studies demonstrating recall bias has a negative effect on the accuracy of data provided after an event (Fanchini et al., 2016; Scantlebury et al., 2018). Although data reporting straight after training would be optimal, it is not always in the forefront of the player's minds when they complete training and they will often have other pressing commitments. Our findings may differ due to smaller amounts of throws being reported at training. Having fewer throws to report on minimises the effect of error greatly, as 10% error of 30 throws is much less and if the athletes were reporting on 100 throws for the session. Our findings may be different if the throwing proportion of training was more significant. The findings of our study provide further evidence that alternative methods of determining throwing volume should be sourced to reduce self-reporting load on the players and improve the accuracy of data recorded (Murphy et al., 2021).

Due to the higher risk of fast bowlers to lumbar stress fractures, Cricket Australia has mandated that they accurately self-report bowling workloads. Therefore, it was expected that these players would have better recall ability than other positions (Dennis et al., 2005). However, no difference was detected in accuracy between playing position.

Female cricket players, tend to be contracted part-time, and therefore have different workload commitments to male players. They often have to manage additional work and/or school responsibilities on top of their cricket careers, resulting in lower training time available in comparison to male players (Laura, 2021). We theorised that this difference in social construct may influence the accuracy of self-reporting throwing loads. However, no differences were detected between females and males in their self-reported throwing load accuracy. Differences were seen in the structure of training influencing the total amount of throws performed.

This thesis presents several implications of clinical significance to elite cricket. Firstly, high-performance staff and players should determine whether the inadequate accuracy of self-reported throwing data justifies the burden placed on players. One method to reduce the burden may be exploring other methods of quantifying throwing loads such as GPS or throwing diaries to capture the number of throws within a session which have been reported that have better accuracy than found for self-reports throwing loads (Dennis et al., 2004; Orchard et al., 2015a). Secondly, high-performance staff and athletes should determine and subsequently implement measures to ensure more timely recording of player-reported throwing loads.

5.1 Limitations

The COVID-19 pandemic hindered the collection of data for this research project. Interstate player hubs meant that recruitment was limited and resulted in the inclusion of fewer female players than originally planned. However, while we had initially aimed for a 50:50 split of females and males this study had a female: male ratio of 8:18 (31% female) which is comparable to the proportion of 2020-2021 contracted Western Australia state Cricket players 14:26 (35% female) (Western Australian Cricket Association Staff Writers, 2022).

The reduced sample resulted the study being underpowered to perform more complex statistical analyses which would have permitted the examination of the influence of delaying self-report entries of throwing load, player position and sex. A larger sample size would be required for further research. The time between session and self-reported throws was not examined statistically as only three players reported more than two days post session. Time to self-reported throws was estimated using a 24-hour window recorded as day of throw, next day, and more than one day post, hence it was limited in accuracy beyond a daily count.

This study was methodologically robust yet simple. However, the primary aim to validate self-reported throwing volume as a tool for load monitoring was heavily reliant on adherence from the players to self-report their throwing loads and unfortunately 3/26 players did not record throwing loads, limiting the sample for analyses.

The impact of the COVID-19, beyond recruitment difficulties, was not assessed. Specifically, no comparison was possible between the training regimes and whether these were typical of non COVID-19 training regimes. As the study was occurring in the dynamic and evolving COVID-19 environment, it was not foreseen to undertake measures to understand the psychological impacts outside of the cricket training environment that might have had an impact on the study outcomes (Bhoyroo et al., 2021).

5.2 Conclusion

In this study a moderate positive correlation was found between player self-reported and observed throws in training, however there was limited agreement between the variables. Therefore, the applicability of player self-report to accurately monitor an elite cricket player's throwing load appears to have limited application. The accuracy and time of upload of self-reported throws showed trivial results, with women uploading their self-reported data sooner than men. There was no observed difference between females and males in relation to self-reported accuracy, and there was only a possible relationship between playing position and accurate self-reported throws.

5.3 Practical Implications

The outcomes from this research have three main practical applications. Firstly, although there is a relationship between self-reported and observed throwing loads, poor accuracy questions its usefulness for player load monitoring. Secondly, high-performance staff and the players should determine if the current accuracy of self-reported throwing volume justifies the additional reporting burden on the players. Finally, if the self-reported data is justified, then limiting recall bias for data upload time may need to take place to increase self-reported accuracy, as a moderate proportion of elite cricket players upload data more than one day post training.

5.4 Future Research

From the findings of this thesis future research should look to:

- Further investigate the interplay of sex on self-report error, as our capacity to perform statistically powered analysis was impeded by Covid-19 and athlete availability.
- Minimise the effect of biases (e.g. Social desirable bias, recall bias, Hawthorne effect) and account for potential bias in analysis to ensure 'real world' results.

- Further explore the relationship between player position and self-report accuracy. Since we detected a possible relationship between playing position and accuracy of self-reporting, further research is needed to confirm or refute our findings.
- Perform a large scale Australia wide study.

References

Abdalla, S., Abdelgadir, N., Shahraz, S., & Bhalla, K. (2015). Respondents' recall of injury events: an investigation of recall bias in cross-sectional injury data from the Sudan Household Health Survey 2010. *Int J Inj Contr Saf Promot, 22*(3), 215-223. https://doi.org/10.1080/17457300.2014.908222

Adirim, T. A., & Cheng, T. L. (2003). Overview of injuries in the young athlete. *Sports Med, 33*(1), 75-81. https://doi.org/10.2165/00007256-200333010-00006

Agel, J., Palmieri-Smith, R. M., Dick, R., Wojtys, E. M., & Marshall, S. W. (2007, Apr-Jun). Descriptive epidemiology of collegiate women's volleyball injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2003-2004. *J Athl Train, 42*(2), 295-302. https://www.ncbi.nlm.nih.gov/pubmed/17710179

Arora, M., Paoloni, J. A., Kandwal, P., & Diwan, A. D. (2014, Dec). Are Fast-Bowlers Prone to Back Injuries? Prevalence of Lumbar Spine Injuries in Fast-Bowlers: Review of MRI-Based Studies. *Asian J Sports Med, 5*(4), e24291. https://doi.org/10.5812/asjsm.24291

Asker, M., Brooke, H. L., Walden, M., Tranaeus, U., Johansson, F., Skillgate, E., & Holm, L. W. (2018, Oct). Risk factors for, and prevention of, shoulder injuries in overhead sports: a systematic review with best-evidence synthesis. *Br J Sports Med, 52*(20), 1312-1319. https://doi.org/10.1136/bjsports-2017-098254

Aylesworth, L., & Kuo, T.-C. (2018). Reporting time period matters: quantifying catch rates and exploring recall bias from fisher interviews in Thailand. *Canadian journal of fisheries and aquatic sciences, 75*(12), 2114-2122. https://doi.org/10.1139/cjfas-2017-0169

Bahr, R., Clarsen, B., Derman, W., Dvorak, J., Emery, C. A., Finch, C. F., Hagglund, M., Junge, A., Kemp, S., Khan, K. M., Marshall, S. W., Meeuwisse, W., Mountjoy, M., Orchard, J. W., Pluim, B., Quarrie, K. L., Reider, B., Schwellnus, M., Soligard, T., Stokes, K. A., Timpka, T., Verhagen, E., Bindra, A., Budgett, R., Engebretsen, L., Erdener, U., & Chamari, K. (2020, Apr). International Olympic Committee consensus statement: methods for recording and reporting of epidemiological data on injury and illness in sport 2020 (including STROBE Extension for Sport Injury and Illness Surveillance (STROBE-SIIS)). *Br J Sports Med, 54*(7), 372-389. https://doi.org/10.1136/bjsports-2019-101969

Bartlett, R. M. (2003, Sep). The science and medicine of cricket: an overview and update. *J Sports Sci, 21*(9), 733-752. https://doi.org/10.1080/0264041031000140257

Bhoyroo, R., Chivers, P., Millar, L., Bulsara, C., Piggott, B., Lambert, M., & Codde, J. (2021, Oct 26). Life in a time of COVID: a mixed method study of the changes in lifestyle, mental and psychosocial health during and after lockdown in

Western Australians. *BMC public health, 21*(1), 1947. https://doi.org/10.1186/s12889-021-11971-7

Black, G. M., Gabbett, T. J., Cole, M. H., & Naughton, G. (2016, Oct). Monitoring Workload in Throwing-Dominant Sports: A Systematic Review. *Sports Med, 46*(10), 1503-1516. https://doi.org/10.1007/s40279-016-0529-6

Bland, J. M., & Altman, D. G. (2010). Statistical methods for assessing agreement between two methods of clinical measurement. *International journal of nursing studies, 47*(8), 931-936. https://doi.org/10.1016/j.ijnurstu.2009.10.001

Bushnell, B. D., Anz, A. W., Noonan, T. J., Torry, M. R., & Hawkins, R. J. (2010, Apr). Association of maximum pitch velocity and elbow injury in professional baseball pitchers. *Am J Sports Med, 38*(4), 728-732. https://doi.org/10.1177/0363546509350067

Chasimpha, S. J. D., McLean, E. M., Dube, A., McCormack, V., dos-Santos-Silva, I., & Glynn, J. R. (2020). Assessing the validity of and factors that influence accurate self-reporting of HIV status after testing: a population-based study. *AIDS, 34*(6). https://journals.lww.com/aidsonline/Fulltext/2020/05010/Assessing_the_validity_of_and_factors_that.14.aspx

Cherpitel, C. J., Ye, Y., Stockwell, T., Vallance, K., & Chow, C. (2018, Mar). Recall bias across 7 days in self-reported alcohol consumption prior to injury among emergency department patients. *Drug Alcohol Rev, 37*(3), 382-388. https://doi.org/10.1111/dar.12558

Cook, D. P., & Strike, S. C. (2000, Dec). Throwing in cricket. *J Sports Sci, 18*(12), 965-973. https://doi.org/10.1080/793086193

Cricket Australia. (2020). *Annual Report 2019-20*.

Cronin, J. B., Sharp, A. P., Stronach, B., Deuchrass, R., Bressel, E., Shackel, D. F., & McMaster, D. T. (2016). Strength and Conditioning for Throwing in Cricket. *Strength & Conditioning Journal, 38*(6), 1-9. https://doi.org/10.1519/ssc.0000000000000254

Dennis, R., Farhart, P., Clements, M., & Ledwidge, H. (2004). The relationship between fast bowling workload and injury in first-class cricketers: A pilot study. *Journal of science and medicine in sport, 7*(2), 232-236. https://www.sciencedirect.com/science/article/abs/pii/S1440244004800148

Dennis, R. J., Finch, C. F., & Farhart, P. J. (2005, Nov). Is bowling workload a risk factor for injury to Australian junior cricket fast bowlers? *Br J Sports Med, 39*(11), 843-846; discussion 843-846. https://doi.org/10.1136/bjsm.2005.018515

Dick, R., Sauers, E. L., Agel, J., Keuter, G., Marshall, S. W., McCarty, K., & McFarland, E. (2007, Apr-Jun). Descriptive epidemiology of collegiate men's baseball injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2003-2004. *J Athl Train, 42*(2), 183-193. https://www.ncbi.nlm.nih.gov/pubmed/17710166

Dutton, M., Gray, J., Prins, D., Divekar, N., & Tam, N. (2020, May). Overhead throwing in cricketers: A biomechanical description and playing level considerations. *J Sports Sci, 38*(10), 1096-1104. https://doi.org/10.1080/02640414.2020.1741973

Eckard, T. G., Padua, D. A., Hearn, D. W., Pexa, B. S., & Frank, B. S. (2018, Aug). The Relationship Between Training Load and Injury in Athletes: A Systematic Review. *Sports Med, 48*(8), 1929-1961. https://doi.org/10.1007/s40279-018-0951-z

Enger, M., Skjaker, S. A., Nordsletten, L., Pripp, A. H., Melhuus, K., Moosmayer, S., & Brox, J. I. (2019). Sports-related acute shoulder injuries in an urban population. *BMJ Open Sport Exerc Med, 5*(1), e000551. https://doi.org/10.1136/bmjsem-2019-000551

English, P. (2011, 2011/12/01). Twenty20 and the changing face of Australian cricket. *Sport in Society, 14*(10), 1369-1382. https://doi.org/10.1080/17430437.2011.620378

Faigenbaum, A. D., & Myer, G. D. (2012). Kid Stuff. *ACSM's health & fitness journal, 16*(5), 9-16. https://doi.org/10.1249/FIT.0b013e318264cac8

Fanchini, M., Ferraresi, I., Petruolo, A., Azzalin, A., Ghielmetti, R., Schena, F., & Impellizzeri, F. M. (2016, 2017/01/02). Is a retrospective RPE appropriate in soccer? Response shift and recall bias. *Science and Medicine in Football, 1*(1), 53-59. https://doi.org/10.1080/02640414.2016.1231411

Finch, C. (2006, May). A new framework for research leading to sports injury prevention. *J Sci Med Sport, 9*(1-2), 3-9; discussion 10. https://doi.org/10.1016/j.jsams.2006.02.009

Fulton, J., Wright, K., Kelly, M., Zebrosky, B., Zanis, M., Drvol, C., & Butler, R. (2014, Oct). Injury risk is altered by previous injury: a systematic review of the literature and presentation of causative neuromuscular factors. *International journal of sports physical therapy, 9*(5), 583-595. https://www.ncbi.nlm.nih.gov/pubmed/25328821

Giavarina, D. (2015). Understanding Bland Altman analysis. *Biochem Med (Zagreb), 25*(2), 141-151. https://doi.org/10.11613/BM.2015.015

Gonyea, R. M. (2005). Self-reported data in institutional research: Review and recommendations. *New directions for institutional research, 2005*(127), 73-89. https://doi.org/10.1002/ir.156

Hulley, S., Cummings, S., Browner, W., Grady, D., & Newman, T. (2013). Designing clinical research (vol. 4th). *Philadelphia: LWW*.

International Cricket Council. (2018). *First global market research project unveils more than one billion cricket fans*. https://www.icc-cricket.com/media-releases/759733

International Cricket Council. (2019). *ICC Test Match Playing Conditions (incorperating the 2017 Cond of the MCC Laws of Cricket)* (International Cricket Council, Ed.) https://www.icc-cricket.com/about/cricket/rules-and-regulations/playing-conditions

International Cricket Council. (2020). *ICC Women's One Day International Playing Conditions* (International Cricket Council, Ed.) https://www.icc-cricket.com/about/cricket/rules-and-regulations/playing-conditions

Jones, C. M., Griffiths, P. C., & Mellalieu, S. D. (2017, May). Training Load and Fatigue Marker Associations with Injury and Illness: A Systematic Review of Longitudinal Studies. *Sports Med, 47*(5), 943-974. https://doi.org/10.1007/s40279-016-0619-5

Laura, J. (2021). *Choose to Challenge: The long path to professionalism*. Cricket Australia. https://www.cricket.com.au/news/choose-to-challenge-womens-cricket-contracts-pay-conditions-professionalism-iwd-part-1/2021-03-01

Lyman, S., Fleisig, G. S., Andrews, J. R., & Osinski, E. D. (2002, Jul-Aug). Effect of pitch type, pitch count, and pitching mechanics on risk of elbow and shoulder pain in youth baseball pitchers. *Am J Sports Med, 30*(4), 463-468. https://doi.org/10.1177/03635465020300040201

Lyman, S., Fleisig, G. S., Waterbor, J. W., Funkhouser, E. M., Pulley, L., Andrews, J. R., Osinski, E. D., & Roseman, J. M. (2001, Nov). Longitudinal study of elbow and shoulder pain in youth baseball pitchers. *Med Sci Sports Exerc, 33*(11), 1803-1810. https://doi.org/10.1097/00005768-200111000-00002

MacDonald, D., Cronin, J., Mills, J., McGuigan, M., & Stretch, R. (2013). A review of cricket fielding requirements. *South African Journal of Sports Medicine, 25*(3), 87-92.

MacDonald Wells, D. C., Cronin, J. B., & Macadam, P. (2018). Key match activities of different fielding positions and categories in one-day international cricket. *International journal of performance analysis in sport, 18*(4), 609-621. https://doi.org/10.1080/24748668.2018.1501994

Matsuura, T., Iwame, T., Suzue, N., Arisawa, K., & Sairyo, K. (2017, May). Risk factors for shoulder and elbow pain in youth baseball players. *Phys Sportsmed, 45*(2), 140-144. https://doi.org/10.1080/00913847.2017.1300505

McCambridge, J., Witton, J., & Elbourne, D. R. (2014, Mar). Systematic review of the Hawthorne effect: new concepts are needed to study research participation effects. *J Clin Epidemiol, 67*(3), 267-277. https://doi.org/10.1016/j.jclinepi.2013.08.015

McQuillan, R., & Campbell, H. (2006, Aug). Gender differences in adolescent injury characteristics: a population-based study of hospital A&E data. *Public Health, 120*(8), 732-741. https://doi.org/10.1016/j.puhe.2006.02.011

Murphy, M. C., Chivers, P., Mahony, K., & Mosler, A. B. (2020). Risk factors for dominant-shoulder injury in elite female Australian cricket players: A prospective study. *Translational Sports Medicine, 3*(5), 404-414.

Murphy, M. C., Glasgow, P., & Mosler, A. B. (2021, Aug). Self-reported measures of training exposure: can we trust them, and how do we select them? *Br J Sports Med, 55*(16), 891-892. https://doi.org/10.1136/bjsports-2021-104498

Nancarrow, C., & Brace, I. (2000). Saying the "right thing": Coping with social desirability bias in marketing research. *Bristol Business School Teaching and Research Review, 3*(11), 1-11.

Nikolaidis, P. T., & Knechtle, B. (2020, Dec). Validity of Recreational Marathon Runners' Self-Reported Anthropometric Data. *Percept Mot Skills, 127*(6), 1068-1078. https://doi.org/10.1177/0031512520930159

Orchard, J. W., Blanch, P., Paoloni, J., Kountouris, A., Sims, K., Orchard, J. J., & Brukner, P. (2015a, Aug). Cricket fast bowling workload patterns as risk factors for tendon, muscle, bone and joint injuries. *Br J Sports Med, 49*(16), 1064-1068. https://doi.org/10.1136/bjsports-2014-093683

Orchard, J. W., Blanch, P., Paoloni, J., Kountouris, A., Sims, K., Orchard, J. J., & Brukner, P. (2015b, Jan). Fast bowling match workloads over 5-26 days and risk of injury in the following month. *J Sci Med Sport, 18*(1), 26-30. https://doi.org/10.1016/j.jsams.2014.09.002

Orchard, J. W., James, T., & Portus, M. R. (2006, Dec). Injuries to elite male cricketers in Australia over a 10-year period. *J Sci Med Sport, 9*(6), 459-467. https://doi.org/10.1016/j.jsams.2006.05.001

Orchard, J. W., Kountouris, A., & Sims, K. (2016). Incidence and prevalence of elite male cricket injuries using updated consensus definitions. *Open access journal of sports medicine, 7*, 187. https://www.dovepress.com/getfile.php?fileID=34042

Owens, B. D., Agel, J., Mountcastle, S. B., Cameron, K. L., & Nelson, B. J. (2009, Sep). Incidence of glenohumeral instability in collegiate athletics. *Am J Sports Med, 37*(9), 1750-1754. https://doi.org/10.1177/0363546509334591

Oz, Y., Arslan, M., Gevrek, T. N., Sanyal, R., & Sanyal, A. (2016, Aug 3). Modular Fabrication of Polymer Brush Coated Magnetic Nanoparticles: Engineering the Interface for Targeted Cellular Imaging. *ACS Appl Mater Interfaces, 8*(30), 19813-19826. https://doi.org/10.1021/acsami.6b04664

Pardiwala, D. N., Rao, N. N., & Varshney, A. V. (2018, May/Jun). Injuries in Cricket. *Sports Health, 10*(3), 217-222. https://doi.org/10.1177/1941738117732318

Petersen, C., Pyne, D., Portus, M., & Dawson, B. (2009, Sep). Validity and reliability of GPS units to monitor cricket-specific movement patterns. *Int J Sports Physiol Perform, 4*(3), 381-393. https://doi.org/10.1123/ijspp.4.3.381

Petersen, C. J., Pyne, D. B., Dawson, B. T., Kellett, A. D., & Portus, M. R. (2011, May). Comparison of training and game demands of national level cricketers. *J Strength Cond Res, 25*(5), 1306-1311. https://doi.org/10.1519/JSC.0b013e3181d82cfd

Petersen, C. J., Pyne, D. B., Portus, M. R., & Dawson, B. T. (2011, May). Comparison of player movement patterns between 1-day and test cricket. *J Strength Cond Res, 25*(5), 1368-1373. https://doi.org/10.1519/JSC.0b013e3181da7899

Phibbs, P. J., Roe, G., Jones, B., Read, D. B., Weakley, J., Darrall-Jones, J., & Till, K. (2017, Apr). Validity of Daily and Weekly Self-Reported Training Load Measures in Adolescent Athletes. *J Strength Cond Res, 31*(4), 1121-1126. https://doi.org/10.1519/JSC.0000000000001708

Pote, L., & Christie, C. J. (2018). Injury Prevention Strategies in Cricket. *Strength & Conditioning Journal, 40*(5), 34-43. https://doi.org/10.1519/ssc.0000000000000409

Ranson, C., & Gregory, P. L. (2008, Feb). Shoulder injury in professional cricketers. *Phys Ther Sport, 9*(1), 34-39. https://doi.org/10.1016/j.ptsp.2007.08.001

Roethlisberger, F. J., & Dickson, W. J. (2003). *Management and the Worker* (Vol. 5). Psychology press.

Saw, A. E., Main, L. C., & Gastin, P. B. (2015). Monitoring athletes through self-report: Factors influencing implementation. *Journal of sports science & medicine, 14*(1), 137.

Saw, A. E., Main, L. C., & Gastin, P. B. (2016, Mar). Monitoring the athlete training response: subjective self-reported measures trump commonly used objective measures: a systematic review. *Br J Sports Med, 50*(5), 281-291. https://doi.org/10.1136/bjsports-2015-094758

Saw, R., Dennis, R. J., Bentley, D., & Farhart, P. (2011, Aug). Throwing workload and injury risk in elite cricketers. *Br J Sports Med, 45*(10), 805-808. https://doi.org/10.1136/bjsm.2009.061309

Scantlebury, S., Till, K., Sawczuk, T., Phibbs, P., & Jones, B. (2018, Jul). Validity of Retrospective Session Rating of Perceived Exertion to Quantify Training Load in youth Athletes. *J Strength Cond Res, 32*(7), 1975-1980. https://doi.org/10.1519/JSC.0000000000002099

Scott, K., Kingsbury, D., Bennett, S., Davids, K., & Langley, M. (2000, Oct). Effects of cricket ball colour and illuminance levels on catching behaviour in professional cricketers. *Ergonomics, 43*(10), 1681-1688. https://doi.org/10.1080/001401300750004087

Stopher, P. R. (2012). *Collecting, managing, and assessing data using sample surveys*. Cambridge University Press.

Stretch, R. A. (2003, Jun). Cricket injuries: a longitudinal study of the nature of injuries to South African cricketers. *Br J Sports Med, 37*(3), 250-253; discussion 253. https://doi.org/10.1136/bjsm.37.3.250

Sytema, R., Dekker, R., Dijkstra, P. U., ten Duis, H. J., & van der Sluis, C. K. (2010). Upper Extremity Sports Injury: Risk Factors in Comparison to Lower Extremity Injury in More Than 25 000 Cases. *Clinical Journal of Sport Medicine, 20*(4). https://journals.lww.com/cjsportsmed/Fulltext/2010/07000/Upper_Extremity_Sports_Injury__Risk_Factors_in.3.aspx

Vickery, W., Duffield, R., Crowther, R., Beakley, D., Blanch, P., & Dascombe, B. J. (2018, Mar). Comparison of the Physical and Technical Demands of Cricket Players During Training and Match-Play. *J Strength Cond Res, 32*(3), 821-829. https://doi.org/10.1519/JSC.0000000000001528

Walker, H. L., Carr, D. J., Chalmers, D. J., & Wilson, C. A. (2010, Nov). Injury to recreational and professional cricket players: circumstances, type and potential for intervention. *Accid Anal Prev, 42*(6), 2094-2098. https://doi.org/10.1016/j.aap.2010.06.022

Warren, A., Dale, S., McCaig, S., & Ranson, C. (2019, Jul). Injury profiles in elite women's T20 cricket. *J Sci Med Sport, 22*(7), 775-779. https://doi.org/10.1016/j.jsams.2019.01.018

Western Australian Cricket Association Staff Writers. (2022). *State Squads Announced*. https://www.waca.com.au/news/state-squads-announced/2020-06-22

Wilk, K. E., Macrina, L. C., Fleisig, G. S., Aune, K. T., Porterfield, R. A., Harker, P., Evans, T. J., & Andrews, J. R. (2015, Oct). Deficits in Glenohumeral Passive Range of Motion Increase Risk of Shoulder Injury in Professional Baseball Pitchers: A Prospective Study. *Am J Sports Med, 43*(10), 2379-2385. https://doi.org/10.1177/0363546515594380

Woods, T. E., Raynor, J. A., Bruce, L., & McDonald, Z. (2015, 2015/07/03). The use of skill tests to predict status in junior Australian football. *J Sports Sci, 33*(11), 1132-1140. https://doi.org/10.1080/02640414.2014.986501

Appendices

Appendix A

The University of Notre Dame Australia Hyman Research Ethics Committee Acceptance

THE UNIVERSITY OF NOTRE DAME AUSTRALIA
19 Mouat St (PO Box 1225) Fremantle WA 6959
+61 8 9433 0555 | enquiries@nd.edu.au

24 August 2020

Dr Ashley Cripps & Zachariah Hoyne
School of Health Sciences
The University of Notre Dame Australia
Fremantle Campus

Dear Ashley and Zachariah,

Reference Number: 2020-114F

Project Title: "The comparison between self-reported and objectively measured throwing loads in elite, Australian cricket players."

Your response to the conditions imposed by a sub-committee of the University of Notre Dame Human Research Ethics Committee (HREC) has been reviewed in accordance with the *National Statement on Ethical Conduct in Human Research* (2007, updated 2018). I am pleased to advise that ethics approval has been granted for this proposed study.

Other researchers identified as working on this project are:

Name	School/Centre	Role
Dr Chris Joyce	School of Health Sciences	Co-Supervisor
Myles Murphy	School of Physiotherapy	Co-Supervisor
Dr Andrea Mosler	La Trobe University	Co-Supervisor

All research projects are approved subject to standard conditions of approval.
Please read the attached document for details of these conditions.

On behalf of the Human Research Ethics Committee, I wish you well with your study.

Yours sincerely,

[redacted]

Dr Natalie Giles
Research Ethics Officer
Research Office

cc: A/Prof Fleur McIntyre, SRC Chair, School of Health Sciences

Broome Campus 88 Guy St (PO Box 2287) Broome WA 6725
Sydney Campus 140 Broadway (PO Box 944) NSW 2007

Fremantle Broome Sydney

ABN 69 330 643 210 | CRICOS Provider Code: 01032F

nd.edu.au

Appendix B

Ethical Considerations

This study has ethical consideration from the University of Notre Dame Australia Human Research Ethics Committee (Approval Number: 2020-114F) and the Cricket Australia Research Committee (Approval Number: A2.3). As players were required to be blinded to the purposes of the study to avoid influencing results a waiver of consent was approved for data collection. However, the players were made aware of the research study after data was collected and were given an opt-out form. No players decided to opt out from the research study.

Appendix C

Participant Information Sheet

THE UNIVERSITY OF NOTRE DAME AUSTRALIA

PARTICIPANT INFORMATION SHEET

Validity of self-reported throws as a measure of throwing load in elite cricket players

You have participated in the research project described below.

What is the project about?

This research project is investigating throwing characteristics of elite cricketers during regular training and the validity of self-report throw counts for monitoring throwing load during training. Currently it is unclear whether the self-reported throwing loads used by Cricket Australia represent a valid tool for monitoring throwing loads. It is important that all tools used in load monitoring are valid as this information is used to adjust athlete's workloads in order to enhance performance and reduce injury risks.

Who undertook the project?

This project is being conducted by Zachariah Hoyne and will form the basis for the degree of Master of Philosophy in Health Science at The University of Notre Dame Australia, under the supervision of Dr. Ashley Cripps, Dr. Chris Joyce, Mr. Myles Murphy and Dr. Andrea Mosler.

How have I contributed?

In your Cricket Australia contract you consent to take part in research studies, it is important that you understand the purpose of the study and what you were recorded doing. Please make sure that you ask any questions you may have and that all your questions have been answered to your satisfaction.

During training you were observed by the research team with the number and type of throws you performed during the session recorded. This includes the distance of the throw, the type of throw performed (warm up throw, throw down and drill throwing) as well as the accuracy of each throw. These observed throwing outcomes, with your consent, will be compared to your self-reported throwing loads recorded on the GER AMS. This comparison will enable us to assess the validity of the self-reported measure as a load monitoring tool.

Are there any risks associated with participating in this project?

There is no foreseeable risk in you participating in this research project. All data will be de-identified prior to analysis.

What are the benefits of the research project?

By participating your data will enable us to critically evaluate the throwing load monitoring measures used by Cricket Australia. Findings will ensure the Sport Science and Medicine Staff are using valid methods of load monitoring to ultimately enhance athletic performance and manage injury risks.

What if I do not wish to participate?

Participation in this study is completely voluntary. You are free to withdraw from participation at any time without giving a reason and with no negative consequences prior to the completion of data collection. No identifiable information will be reported on.

Will anyone else know the results of the project?

Information gathered about you will be held in strict confidence. This confidence will only be broken if required by law.

Your information will be kept on the University campus, on a password protected hard drive on a password protected computer. Only Zachariah Hoyne will have access to your information and will only be used for comparison of your self-reported number of throws and observed number of throws. The stored data will be non-identifiable.

Once the study is completed, the data collected from you will be de-identified and stored securely in the School of Health Science at The University of Notre Dame Australia for at least a period of five years. The data may be used in future research but you will not be able to be identified. The results of the study will be published as a journal article and thesis. A de-identified summary of results will be supplied to Cricket Australia.

Will I be able to find out the results of the project?

Once we have analysed the information from this study we will email a summary of our findings. You can expect to receive this feedback in mid 2021.

Who do I contact if I have questions about the project?

If you have any questions about this project please feel free to contact Zachariah Hoyne at [redacted] or 20172822@my.nd.edu.au Alternatively, you can contact Ashley Cripps at 9433 0201 or ashley.cripps@nd.edu.au. We are happy to discuss with you any concerns you may have about this study.

What if I have a concern or complaint?

The study has been approved by the Human Research Ethics Committee at The University of Notre Dame Australia (approval number 2020-114F). If you have a concern or complaint regarding the ethical conduct of this research project and would like to speak to an independent person, please contact Notre Dame's Research Ethics Officer at (+61 8) 9433 0943 or research@nd.edu.au. Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome.

Thank you for your time. This sheet is for you to keep.

Yours sincerely,

[redacted]

Zachariah Hoyne