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THE UNIVERSITY OF NOTRE DAME AUSTRALIA

The Validity and Reliability of the Basketball Jump Shooting Accuracy Test

This thesis is presented for the degree of Master of Philosophy at The University of Notre Dame Australia, Fremantle

School of Health Sciences

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Co-Supervisor: Dr Aaron Scanlan

Submitted May 2019

Statement of Original Contribution

I declare this thesis is the candidate's own work and does not contain without acknowledgement any material which has been accepted for the award of any degree or diploma in any other institution.

To the best of the candidate's knowledge, this thesis contains no material previously published or written by another person, except where due reference is made in the text.

Signature: ……. **Date:** 8/5/19

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Table of Contents

List of Tables

List of Figures

List of Abbreviations

AAHPERD	American Alliance for Health, Physical Education, Recreation and Dance
AFK	Australian Football Kicking
AFL	Australian Football League
BJSAT	Basketball Jump Shooting Accuracy Test
CBST	Combined Basketball Skill Test
CI	Confidence Intervals
CMJ	Counter Movement Jump
CV	Coefficient of Variation
ICC	Intra-Class Correlation Coefficient
NBA	National Basketball Association
NBL	National Basketball League
NCAA	National Collegiate Athletic Association
SBL	State Basketball League
SD	Standard Deviation
SEM	Standard Error of Measurement
SPSS	Statistical Package for Social Sciences
SWC	Smallest Worthwhile Change
TE	Typical Error

Thesis Overview

Jump shooting is a fundamental basketball skill performed by athletes of all playing positions (guard, forward, and centre) throughout game-play (Zhang et al., 2017). The jump shot is defined as any shot where both feet remain in contact with the court before the jumping motion is initiated with both hands placed on the basketball until the release phase (Okazaki, Rodacki, & Satern, 2015). The jump shot is not only the most common shot type in basketball accounting for 67% of all shots attempted in the 2014-15 National Basketball Association (NBA) season (Erculj & Strumbelj, 2015), but also significantly influences match outcomes with a team's winning probability increased when superior two- and three-point shooting accuracy is exhibited compared to the opposing team (Özmen, 2016). Though the importance of accurate jump shooting is evident in the literature (Ibáñez et al., 2008; Lorenzo, Gomez, Ortega, Ibanez, & Sampaio, 2010; Özmen, 2016), a gold-standard shooting accuracy assessment for application in basketball is currently lacking. Many existing assessments assess two- and three-point accuracy independently, which is not representative of shooting demands during game-play as shots alternate between both distances (Gomez, Gasperi, & Lupo, 2017). Another limitation of current assessments is the ambiguous information presented in published research regarding existing testing protocols, which limits the reproducibility of these assessments in practice. These limitations in current shooting tests has led to the development of the Basketball Jump Shooting Accuracy Test (BJSAT), which was designed to evaluate jump shooting accuracy from various court locations and distances while alternating between shots from two- and three-point distances. Before utilisation in the field however, the BJSAT was examined for validity and reliability outcomes.

Chapter two of this thesis presents a review of the current literature beginning with an introduction to basketball including game regulations and the physical demands of the sport. Common technical tasks in basketball are then discussed with an emphasis

on jump shooting given the importance of this skill during game-play (Erculj & Strumbelj, 2015) and the positive influence of accurate jump shooting on match outcomes (Özmen, 2016). Technical assessments in sport are also discussed in this chapter highlighting how such tests can be utilised by practitioners. Finally, existing jump shooting assessments are reviewed with the key findings and limitations of each test presented.

Chapter three of this thesis discusses the development of the BJSAT and examines the intra- and inter-rater reliability of the assessment. Findings from this chapter revealed an *almost perfect* agreement for intra-rater reliability demonstrating scores awarded live in person are predominantly similar to those given by the same assessor when watching video footage. A *substantial* agreement was shown for inter-rater reliability of the BJSAT, highlighting the assessment can be reliably scored by different assessors. This finding is important as the same assessor may not be available each time the test is conducted throughout the season. Floor and ceiling effects were also analysed and shown to be absent during the BJSAT with 98% of intra-rater and 97% of inter-rater reliability scores positioned in the second and third quartiles. This outcome demonstrates the suitability of the BJSAT to the population assessed as the assessment was not too easy or difficult to perform.

Chapter four of this thesis examines the content validity, construct validity, and test-retest reliability of the BJSAT, all identified as important measurement properties for newly- established skill tests in sport (Robertson, Burnett, & Cochrane, 2014). A significant, *large* ($d = 0.99$, $p < 0.01$) difference was found in BJSAT scores between two- and three-point shots. Meanwhile, there was a non-significant, *trivial* difference in BJSAT score between gender ($d = 0.17$, $p = 0.57$) and playing level ($d = 0.15$, $p = 0.70$). Relative reliability was rated as *moderate* for all athletes (ICC = 0.71, $p < 0.01$), showing

sufficient reliability when using the average of repeated scores. Absolute reliability was above the accepted benchmark deemed for CV measures in the literature (Atkinson & Nevill, 1998) (CV = 16.2%); however, this outcome is not uncommon due to the inconsistencies in skill accuracy displayed by athletes during competition. Jump shooting accuracy was more reliable completing two-point shots (ICC = 0.68, $p < 0.01$, CV = 19.8%) compared to three-point shots (ICC = 0.58, $p < 0.01$, CV = 20.0%), highlighting the BJSAT produces similar shooting performance trends to those observed during game-play where shooting accuracy is superior from closer distances (Özmen, 2016).

Chapter five is the final chapter of the thesis and summarises the key findings of chapters three and four. Recommendations to practitioners are presented explaining how the BJSAT can be utilised in basketball. Limitations of the thesis are also outlined including the underlying reasons for their occurrence. Future research directions are described in this chapter to provide recommendations for further studies examining application of the BJSAT.

In conclusion, this thesis highlights the lack of valid and reliable jump shooting accuracy assessments for application in basketball despite the importance of the jump shot skill in the sport. Chapters three and four discuss the development of the BJSAT, an assessment developed to address the current limitations of existing shooting tests. Findings from chapter three demonstrate the BJSAT can be reliably assessed by one or multiple assessors while the assessment is suitable for state-level basketball athletes with an absence of floor and ceiling effects. Chapter four demonstrates the BJSAT can discriminate between two- and three-point shots and possesses acceptable relative reliability. Consequently, practitioners can reliably utilise the BJSAT for various purposes such as to longitudinally monitor shooting performance and to assess the efficacy of skill-related or rehabilitation interventions.

Publications Arising From Thesis

Chapter Three

Boddington, B. J., Cripps, A. J., Scanlan, A. T., & Spiteri, T. (2019). Operation of the Basketball Jump Shooting Accuracy Test: Intra- and inter-rater reliability of scoring procedures and floor and ceiling effects for test performance. *International Journal of Sports Science and Coaching, 15*(2), 220-226. doi:10.1177/1747954120902568

Chapter Four

Boddington, B. J., Cripps, A. J., Scanlan, A. T., & Spiteri, T. The validity and reliability of the Basketball Jump Shooting Accuracy Test. *Journal of Sports Sciences, 37*(14), 1648-1654. doi:10.1080/02640414.2019.1582138

Abstract

Valid and reliable jump shooting assessments that replicate in-game shooting performance are currently lacking in basketball. The aims of this thesis were to (1) describe the development of the newly-established Basketball Jump Shooting Accuracy Test (BJSAT), (2) determine the intra- and inter-rater reliability of the BJSAT, and (3) determine the content validity, construct validity, and test-retest reliability of the BJSAT. Basketball athletes from different playing levels (State Basketball League [SBL], n = 30, age: 22.7 ± 6.1 yr; SBL Division I, n = 11, age: 20.6 ± 2.1 yr) completed four trials of the BJSAT with each trial consisting of four two- and four three-point shots from pre-determined court locations. Each shot attempt was scored utilising criteria where greater scores were given when superior accuracy was exhibited. The BJSAT detected a significant, *large* difference in accuracy between two- and three-point shots ($d = 0.99$, $p < 0.01$), representing suitable content validity. However, a non-significant, *trivial* difference was revealed in BJSAT score between gender ($d = 0.17$, $p = 0.57$) and playing level ($d = 0.15$, $p = 0.70$). For intra-rater reliability, there was an *almost perfect* ($\kappa = 0.85$, $p < 0.01$) agreement between scores. The agreement for inter-rater reliability was rated as *substantial* ($\kappa = 0.70$, $p < 0.01$). Relative reliability was rated as *moderate* for all athletes (intraclass correlation coefficient [ICC] = 0.71, $p < 0.01$) and *good* for the SBL athletes (ICC = 0.78, $p < 0.01$) highlighting sufficient reliability of the BJSAT when using the average of repeated scores. Absolute reliability for all athletes was above the acceptable benchmark (coefficient of variation = 16.2%); however this outcome is superior to comparative skill tests available in the literature. Floor and ceiling effects were absent in the BJSAT when one or multiple assessors scored the test. In conclusion, the BJSAT is a skill assessment where one or multiple assessors can reliably score jump shooting performance and is sensitive to two- and three-point shooting accuracy from variable distances and locations, representative of basketball game-play.

Introduction

Basketball is a popular sport played across the world involving a diverse range of physical and technical tasks (Abdelkrim, Chaouachi, Chamari, Chtara, & Castagna, 2010; Scanlan, Dascombe, Reaburn, & Dalbo, 2012). Basketball game-play requires the repeated execution of skills such as passing, rebounding, dribbling, and shooting during periods of repeated, high- and low-intensity activity (Read et al., 2014). Shooting in particular is important to a team's offensive game-play because superior two- and three-point shooting accuracy increases a team's winning probability (Ibáñez, et al., 2008; Lorenzo, et al., 2010; Özmen, 2016). There are a variety of shots performed in basketball competition including the lay-up, dunk, and jump shot; however the jump shot is the most common shot executed, accounting for 67% of all shots attempted in the 2014-15 National Basketball Association (NBA) regular season (Erculj & Strumbelj, 2015). Despite the importance of jump shooting performance to team success, there are few valid and reliable assessments that examine jump shooting accuracy in basketball athletes.

Before utilisation in the field, skill assessments should first be examined for validity and reliability. Validity refers to the degree in which a test measures the skill in question. Specifically, content validity refers to the ability of an assessment to mimic particular actions of a sport (Aandstad & Simon, 2013). Content validity of a jump shooting test in basketball could be examined by comparing test outcomes between shots of varying difficulty. For example, shooting accuracy from two-point distances may be expected to be superior to shots attempted from three-point distances given they are closer to the basket. Shooting accuracy generally declines from greater distances due to the increase in velocity and release angle required on the basketball and the decline in release height (Okazaki & Rodacki, 2012). Construct validity may be assessed by comparing performance outcomes between different groups of athletes where scores would naturally be expected to diverge. For example, when comparing athletes competing at varying

playing levels (Scanlan, Dascombe, & Reaburn, 2012), as shooting accuracy would be expected to be superior in athletes competing at higher levels (Sampaio, Godoy, & Feu, 2004).

Reliability can be examined in a number of ways but generally refers to the consistency of an assessment in measuring the outcome of interest across multiple trials (Robertson, et al., 2014). Relative reliability refers to the consistency of the position of individual scores relative to others in a group while absolute reliability concerns the consistency of scores by each individual (Weir, 2005). In addition to test-retest reliability, examining the reliability of scores when one or multiple assessors administer an assessment further demonstrates the competency of a test. Intra-rater reliability appraises the reliability of a single assessor to score test performance on multiple occasions while inter-rater reliability refers to the level of agreement between two different assessors scoring the same test (Scholtes, Terwee, & Poolman, 2011).

Development of a jump shooting assessment that replicates the variable shots attempted during games and possesses adequate intra- and inter-rater reliability is essential for practitioners to measure the efficacy of technically-focussed training interventions and quantify changes in performance. A common challenge when developing a skill test is balancing the trade-off between validity and reliability where consistent testing conditions are present for each athlete while also ensuring the assessment possesses valid characteristics similar to those seen during game-play. Maintaining a balance between both testing components can be difficult, but nonetheless important to attain. Jump shooting assessments previously utilised in basketball lack validity and reliability analyses, therefore limiting the application of these existing test protocols.

Valid and reliable jump shooting assessments may have wide-ranging applications in basketball either on their own or as part of a multi-dimensional assessment included in the talent identification process (Robertson, et al., 2014) and may assist with skill development in basketball athletes. Individual limitations in jump shooting technique may be identified for each athlete which may assist in the development and implementation of specific skill-enhancing strategies (Robertson, et al., 2014). A simple, repeatable skill assessment may also allow for progress in skill performance to be monitored to assess the effectiveness of implemented training interventions (Sunderland, Cooke, Milne, & Nevill, 2006).

Purpose of this study

The Basketball Jump Shooting Accuracy Test (BJSAT) has been developed in response to limitations in the available shooting tests designed for application in basketball. Existing assessments demonstrate inter-subject variability in testing conditions, provide ambiguous information regarding testing protocols and lack content and/or construct validity. Furthermore, current assessments fail to replicate game-specific shooting patterns in that shots are attempted from the same distance or the locations contained in the tests do not reflect common shooting locations during game-play. The BJSAT is designed to evaluate jump shooting accuracy across game-specific court locations and distances in a replicable manner. Therefore, the aims of this thesis are to (1) describe the development of a newly-established jump shooting accuracy assessment, the BJSAT, (2) determine the intra- and inter-rater reliability of the BJSAT, and (3) determine the content validity, construct validity, and test-retest reliability of the BJSAT.

Significance of this study

This study will contribute to the current gap in literature appertaining to the lack of valid and reliable jump shooting assessments that closely replicate shooting locations and

distances during game-play. Previous assessments have examined the jump shooting accuracy of athletes; however few assessments have contained a combination of two- and three-point shot attempts (Kinc, 2008; Okazaki & Rodacki, 2012; Thakur & Mahesh, 2016). Consequently, the validity of these assessments may be questioned because of the absence of testing characteristics observed during actual basketball game-play. For example, athletes have shown to alternate between two- and three-point shot attempts during game-play rather than attempt shots from a single distance (Gomez, et al., 2017). Therefore, jump shooting assessments examining accuracy from a single distance are not replicating the shooting demands observed in game-play. Meanwhile, the Combined Basketball Skill Test (CBST) includes the serial coupling of skills by examining shooting, passing and dribbling performance (Conte et al., 2018). However, this assessment may be practically difficult to utilise due to the multi-faceted design where multiple skills are examined. Furthermore, with a focus on other skills and shot types such as lay-ups and reverse lay-ups, the level of examination on jump shooting performance may be lessened compared to an assessment that solely focusses on jump shooting.

The limitations of current jump shooting assessments demonstrate the need for a test which focusses solely on the skill of jump shooting combining shots from two- and three-point distance in combination to replicate the demands observed in game-play. The BJSAT aims to address these limitations with the findings of this study providing practitioners with information about the ability of the BJSAT to validly and reliably assess jump shooting accuracy in basketball athletes.

Research Questions/Hypothesis

The following research questions will be investigated in this thesis;

1. Does the BJSAT demonstrate content validity, by discriminating between two- and three-point jump shooting accuracy?

    HO- The BJSAT will not demonstrate any difference between two- and three-point shooting accuracy.

    H1- The BJSAT will demonstrate superior two-point accuracy compared to three-point accuracy.

2. Does the BJSAT demonstrate construct validity, by discriminating between State Basketball League (SBL) and SBL Division I athletes?

    HO- The BJSAT will not discriminate between SBL and SBL Division I athletes.

    H1- SBL athletes will demonstrate superior shooting accuracy compared to SBL Division I athletes.

3. Does the BJSAT demonstrate acceptable reliability for SBL and SBL Division I athletes?

    HO- The BJSAT will not demonstrate acceptable reliability.

    H1- The BJSAT will demonstrate acceptable reliability according to recommendations in the literature.

Limitations

The limitations of this thesis are:

- Although a wide variety of athletes from the recruited teams were included in this thesis, each athlete on a basketball team does not attempt the same number of jump shots in each game with factors such as playing position influencing an athlete's shot attempts (Zhang, et al., 2017). In the BJSAT, all athletes regardless of playing position attempt the same number of jump shots, which may not reflect the shooting demands of game-play for each individual athlete.
- The chosen shot locations in the BJSAT were established using data limited to the NBA, which may not be reflective of common shot locations in other competitions such as the SBL.
- The BJSAT is a pre-planned assessment to control the movement patterns leading into and following shot attempts, whereas shots attempted during game-play are in response to various stimuli such as defensive actions of opponents, game situation and fatigue, with shots performed at random. Consequently, actions preceding jump shot attempts during game-play are not replicated in the BJSAT.

Delimitations

The delimitations of this thesis are:

- This study strived to examine fundamental measurement properties of the BJSAT while replicating common shooting demands experienced during game-play. Therefore, state-level male and female basketball athletes were recruited to undertake the BJSAT, an assessment where each athlete attempts the same number of jump shots for consistent testing protocols.

- Detailed shooting location data utilised for the BJSAT is easily accessible from the NBA, the premier basketball competition in the world and is not available from other competitions such as the SBL.
- To ensure minimal variability in testing conditions, all athletes attempted the same number of jump shots in a pre-planned order, which was made known to each athlete prior to testing.

Chapter Two: Review of Literature

2.1 Introduction to Basketball

Basketball is a globally-recognised team sport where two teams of five athletes compete on a court in an attempt to outscore one another (Federation, 2018). Basketball games consist of four quarters, each lasting between 10-12 minutes, with differences dependent on game regulations determined by the competition's governing body. A basketball court is ~28 m x 15 m with the three-point line 6.75 m from the basket in competitions such as Australia's National Basketball League (NBL) and Europe's Euro League (Federation, 2018), as illustrated in Figure 1. However, differences exist between competitions, for example the three-point line in the NBA is 7.25 m from the basket (Erculj & Strumbelj, 2015). While in the National Collegiate Athletic Association (NCAA) male basketball competition the three-point line is 6.75 m from the basket and 6.32 m in NCAA female competition (NCAA, 2019). Differences in regulations also exist in basket heights with a height of 3.05 m from the top of the basket to the floor observed in senior competitions with reduced basket heights utilised in junior competitions (FIBA, 2014).

On each basketball team, athletes possess a range of physical capabilities which determine the three fundamental playing positions; guards, forwards, and centres. In this regard, forwards and centres are generally taller and possess greater total strength than guards (Abdelkrim, Chaouachi, et al., 2010). Physical differences may exist between playing positions; however each athlete on the court is required to meet the demands of game-play. Basketball game-play involves repeated, explosive movements separated by periods of less intense activity (Read, et al., 2014). Data obtained from a state-level basketball competition in Australia revealed basketball athletes covered 5215 ± 314 m during game-play, which included 456 ± 20 m of walking, 1850 ± 13 m of running and 925 ± 184 m of sprinting (Scanlan, Dascombe, Reaburn, et al., 2012). In addition to these

movements, athletes perform basketball-specific skills including passing, rebounding, dribbling, and shooting throughout game-play.

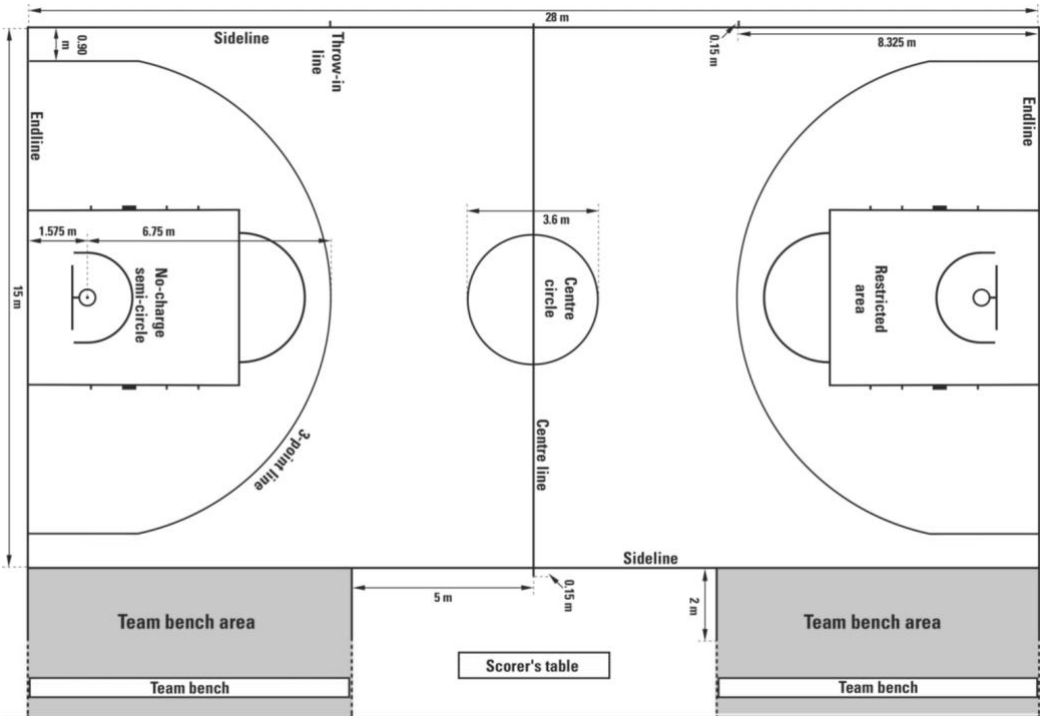

Figure 1. Layout of basketball playing court (International Basketball Federation, 2018, p. 7).

2.2 Technical Demands of Basketball

Passing, rebounding, dribbling, and shooting are four technical tasks inherent to basketball game-play. Previous literature has demonstrated the influence these tasks can have on team success with a team's probability of winning increasing when a greater number of assists are recorded and when greater shooting accuracy is demonstrated in addition to attaining more rebounds than the opposition (Ibáñez, et al., 2008; Özmen, 2016), highlighting the importance of skill execution in each of these tasks.

2.2.1 Passing

Passing is a skill commonly preceding shooting and therefore can dictate the quality of shot attempts. Teams pass the basketball with the aim of maintaining possession and

creating uncontested, successful shot attempts. Passes that directly lead to successful shot attempts are classified as assists with the probability of winning games increasing when a greater number of assists are achieved (Lorenzo, et al., 2010; Melnick, 2001; Özmen, 2016). Inaccurate passing on the other hand can result in a turnover and facilitates steals for the opposition. Turnovers can influence the outcome of games as losing teams average a greater number of turnovers per game than more successful teams (Ibáñez, et al., 2008; Lorenzo, et al., 2010; Özmen, 2016). The two-handed chest pass is the most common type of pass utilised by basketball athletes because it possesses the highest accuracy (Izzo & Russo, 2011).

2.2.2 Rebounding

Rebounding is a technical task which occurs after an unsuccessful shot attempt. An offensive rebound occurs when an athlete rebounds the basketball after a team-mate has been unsuccessful in a shot attempt. Offensive rebounds are typically less common than rebounds occurring after an athlete on the opposing team has attempted a shot, known as a defensive rebound. Defensive rebounding is regarded as an influential task during basketball game-play as teams are able to regain possession and deny the opposition a secondary attempt to score (Ibáñez, et al., 2008; Lorenzo, et al., 2010; Özmen, 2016).

2.2.3 Dribbling

Dribbling allows an athlete to move with the basketball and is performed when the athlete bounces the ball with one hand onto the court and touches the ball again before another athlete touches the ball (Federation, 2018). Generally guards dribble the basketball most frequently compared to other playing positions as shown by previous research where elite guards performed 60 ± 4 dribbling bouts during game-play compared to forwards and centres who completed 23 ± 1 dribbling bouts (Scanlan, Dascombe, & Reaburn, 2011). Furthermore, elite guards undergo dribbling for 3.95 ± 0.36 seconds in each bout, while

forwards and centres dribble for 1.62 ± 0.11 seconds in each bout (Scanlan, et al., 2011). Athletes utilise dribbling to move around an opponent to create a more favourable offensive situation, potentially enabling a shot attempt with less defensive pressure.

2.2.4 Shooting

The objective of basketball competition is to outscore the opposing team highlighting the importance for athletes and teams to demonstrate efficient shooting. Statistical data obtained from two of the most prominent leagues in the world; the NBA and Euro League reveal that the most commonly executed shot type in basketball is the jump shot. Previous literature revealed that 154 total shots were attempted in each NBA game (Erculj & Strumbelj, 2015). The jump shot accounts for 67% of all shots attempted meaning >104 jump shots are typically attempted during game-play (Erculj & Strumbelj, 2015). The high frequency of jump shooting during game-play highlights the skill transcends playing position and at higher levels, proficient jump shooting ability is being demanded by all basketball athletes (Zhang, et al., 2017). It is not just the frequency of jump shot attempts by each team that influences the outcome of games but also the accuracy of jump shots, which is of equal importance. Research has demonstrated that a team's winning probability increases when a greater two-point and three-point shooting accuracy is demonstrated in comparison to the opposing team (Ibáñez, et al., 2008; Lorenzo, et al., 2010; Özmen, 2016).

The jump shot is a skill comprised of five distinct, interrelated phases as illustrated in Figure 2. The initial phase is considered the preparation phase where the body is lowered into a powerful position preparing to jump off the ground. Ball elevation is the second phase where the basketball is elevated and controlled at eye level. Third is the stability phase, where a countermovement jump (CMJ) is performed resulting in both feet breaking contact with the court. The fourth phase is the release phase which is when the

ball is released from the hands before the final phase, deemed the follow-through, is performed where the hands remain pointed at the basket and both feet return to the court (Okazaki, et al., 2015).

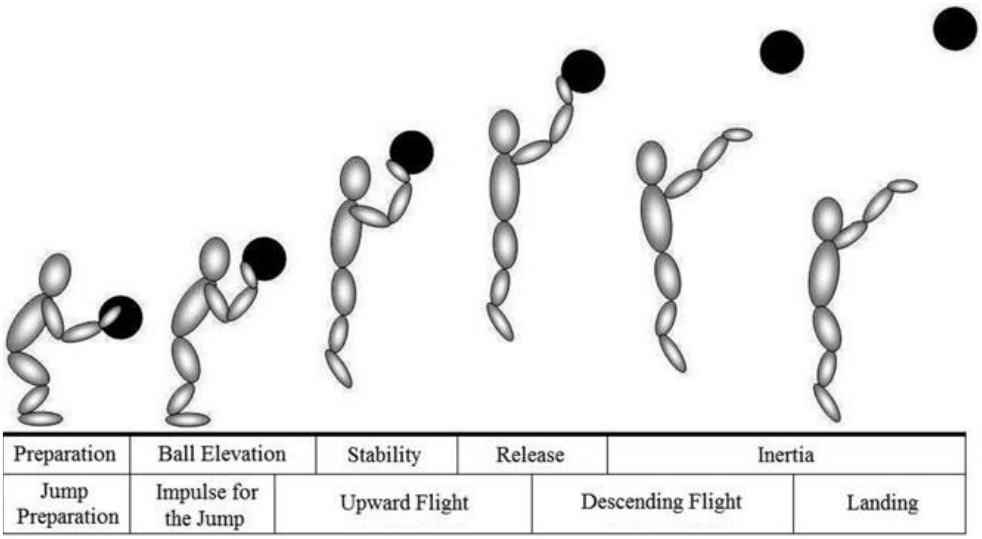

Figure 2. Phases of the basketball jump shot (Okazaki et al., 2015, p. 196).

This chain of movements highlight the dynamic nature of the jump shot, which is further influenced by the constant variability in shooting locations and distances from where shots are executed during game-play (Gomez, et al., 2017). Figure 3 illustrates the positions on the court where athletes attempted a high frequency of jump shots during the 2015-16 NBA season with court locations in red, yellow, green, and blue indicating highest to lowest shooting frequency. The figure clearly reveals the variation in location and distance in which jump shots are commonly executed during basketball game-play.

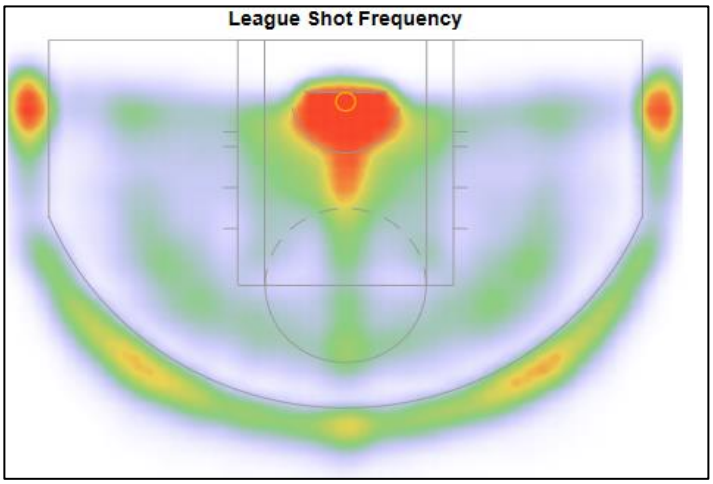

Figure 3. Frequency of shot attempts by court location during the 2015-16 NBA season (Beshai, 2014, p. 11).

Variation in jump shooting technique has been observed in shots attempted from different locations and distances on the court. A previous study examined the effect of increasing shooting distances on shooting technique with athletes attempting ten jump shots in a random order from three distances; close, 2.8 m; intermediate, 4.8 m and long, 6.8 m (Okazaki & Rodacki, 2012). When shooting from longer distances, athletes tend to reduce the release height while increasing the angle and velocity placed upon the basketball during the release phase of the skill (Okazaki & Rodacki, 2012). This variation in movement appears to influence jump shooting accuracy with inferior accuracy demonstrated in shots attempted from greater distances during both testing protocols (37% shooting accuracy from longer distances vs. 59% shooting accuracy from closer distances) (Okazaki & Rodacki, 2012) and basketball competition (35% shooting accuracy from three-point distances vs. 52% shooting accuracy from two-point distances) (Özmen, 2016).

Variability in the constraint of a task is also important to consider when examining jump shooting and is introduced when shots from two- and three-point distance are assessed in combination. Athletes who demonstrate consistency in shooting accuracy under high levels of variability exhibit adaptability to the task which can enhance successful performance outcomes (Serra-Olivares, Gonzalez-Villora, Garcia-Lopez, & Araujo, 2015). Therefore, to thoroughly examine an athlete's jump shooting accuracy while reflecting the shooting patterns and variability of task commonly experienced during game-play, it is necessary to assess accuracy from alternate shooting locations and distances.

2.2 Assessment of Technical Skills

The prevalence and utilisation of skill assessments in sport has become more widespread in recent times as has the areas in which these assessments have been utilised, such as in athlete monitoring, assessing coaching intervention efficacy, and talent identification (Robertson, et al., 2014). When repeatable skill assessments are developed, practitioners utilise them to monitor the skill accuracy of athletes over a period of time. For example, a testing battery in volleyball that evaluated accuracy in four fundamental skills revealed slight changes in skill accuracy across repeated trials (Gabbett & Georgieff, 2006). However, skill accuracy may not improve across different points in time, therefore specific interventions may be introduced before the athlete undertakes the assessment again.

A skill assessment which assesses coaching intervention efficacy can be observed in golf. The Approach-Iron Skill Test consists of two rounds of 30 golf shots from variable distances with feedback provided to the athlete after each attempt (Robertson, Burnett, & Newton, 2013). Feedback can result in a change in technique in the resulting shot attempts allowing practitioners to examine the effectiveness of implemented

strategies. Finally, sporting leagues such as the NBA and Australian Football League (AFL) have introduced skill testing into their annual multidisciplinary events where talent identification staff gather to observe and analyse potential athletes. Each athlete who undertakes a technical assessment is awarded a score based on the desired outcome of the test which allows for objective examination of an athlete (Woods, Raynor, Bruce, & McDonald, 2015). The ability of these assessments to concur with identified talent is evident with 84% of athletes chosen in a state talent academy for Australian football scoring above the receiver operating curve deemed for the Australian Football Kicking (AFK) test, compared to only 24% of athletes not chosen to participate in the academy (Woods, et al., 2015). Evidence suggests that skill assessments can offer various applications to practitioners; however, outcomes and subsequent decisions derived from the assessment may be blemished if adequate validity and reliability are not demonstrated.

Deficiencies in testing methodology and measurement properties significantly impede the usefulness of assessments (Robertson, et al., 2014). Validity and reliability are two considerations which are critical to the efficacy of an assessment (Currell & Jeukendrup, 2008). A trade-off between validity and reliability levels has been observed in technical assessments with those conducted in the field often displaying greater validity but reduced reliability or vice-versa (Reilly, Morris, & Whyte, 2009). For example, it is difficult for practitioners to replicate the conditions and movements observed during actual competition during laboratory-based testing, therefore reducing the validity of the assessment. However, undertaking assessments in the field can reduce reliability as practitioners have less control over factors which may influence outcomes such as unpredictable environmental conditions (Reilly, et al., 2009). Another consideration for newly developed assessments is the trade-off between internal and external validity. To achieve a high internal validity, it is important to establish a sound assessment with limited extraneous variables that can be difficult to control. As a result, external validity

can be lessened which reduces the ability of the assessment to simulate conditions which are observed during actual competition (Atkinson & Nevill, 2001). Maintaining an acceptable balance between these properties is a challenge for newly-developed technical assessments however testing protocols should nonetheless have the capability of examining and displaying acceptable validity and reliability.

Multiple types of validity exist with each predicated on assessing the quality in which an assessment measures what it intends to (Robertson, et al., 2014). Table 1 outlines the difference between common types of validity and how each are commonly measured. Construct validity assesses the ability of a test to discriminate between groups of athletes where differing abilities should be apparent in test performance in regard to the measured construct (Currell & Jeukendrup, 2008). For example, jump shooting accuracy outcomes of an assessment can be evaluated between different playing levels with superior accuracy expected in the higher level. Content validity concerns the degree to which the items of an instrument reflect the constructs in question (Scholtes, et al., 2011). For example, an assessment's ability to discriminate between two- and three-point shooting accuracy in basketball is an approach to assess construct validity. Criterion validity examines the level of agreement between performance in the instrument and relevant competition (Currell & Jeukendrup, 2008). However, due to unreliable match statistics, criterion validity was not examined in this study. Validity of an assessment can be demonstrated if it shows similar trends in skill accuracy compared to game-play. For example, athletes may exhibit superior accuracy from close distances compared to long distances when undertaking an assessment protocol, reflecting shooting performance during game-play. Validity is typically assessed using statistics such as Pearson correlations, which analyse the association between variables (Aandstad & Simon, 2013), t-tests which compare the means of a repeated test (Atkinson & Nevill, 1998) and Cohen's effect sizes, which calculate the magnitude of the difference between variable means

(Cohen, 1992). When examining validity, it is common place to also examine reliability because the utility of a protocol will not be deemed valid if consistent outcomes are not produced across repeated measures (Atkinson & Nevill, 1998).

Table 1.

Descriptions of validity and reliability measures.

Item	Definition	Statistics
Construct validity	The ability of the instrument to differentiate between the construct	Effect size (Cohen's d), t-test
Content validity	The degree in which the instrument reflects the construct	Effect size (Cohen's d), t-test
Criterion validity	The level of agreement between performance in the instrument and a relevant competition	Pearson correlation (r)
Relative reliability	Consistency of test score relative to other group members	Two-way ICC, SEM
Absolute reliability	Consistency of individual test score	CV
Intra-rater reliability	Consistency of test score by one assessor on multiple occasions	Cohen's Kappa
Inter-rater reliability	Level of agreement between different assessors	Cohen's Kappa

Note: ICC = intraclass correlation coefficient; SEM = standard error of the mean; CV = coefficient of variation.

Reliability refers to the reproducibility of an outcome when an assessment is repeated and is therefore an important feature because it demonstrates greater precision when evaluating and monitoring a change in performance (Hopkins, 2000). As a result, practitioners have greater confidence in the interventions placed upon an athlete, such as for the purpose of rehabilitation, because any change in performance is more attributable to the implemented intervention rather than a limitation in the assessment design. Relative and absolute reliability both concern the consistency of an outcome; however, relative reliability concerns the position of individual scores relative to others while absolute reliability solely concerns the score obtained by each individual (Weir, 2005). Reliability measures can also be determined to evaluate the reliability of scores ascertained by the rater of an assessment. In this regard, intra-rater reliability concerns the consistency of an

outcome awarded by one assessor on multiple occasions and inter-rater reliability refers to the level of agreement between different assessors scoring the same instrument (Scholtes, et al., 2011). Reliability is commonly examined using intraclass correlation coefficients (ICC).One-way ICC models are utilised when a subject is assessed by different assessors for a single measure, however this model is rarely utilised in reliability research where the same assessors are typically used to assess all subjects (Koo & Li, 2016). Meanwhile, two-way mixed-effect ICC models are utilised when one or more retests are undertaken. This model is applied when the results only represent the selected assessors involved in the research and cannot be generalised to other assessors (Koo & Li, 2016), as outlined in Table 1. Other common statistical analyses for reliability are standard error of measurement (SEM), which investigates the source of variation in test outcomes and coefficient of variation (CV), which measures the magnitude of deviation from the mean score (Atkinson & Nevill, 1998). Intra- and inter-rater reliability meanwhile are commonly analysed using Cohen's kappa, a method which measures the level of agreement beyond chance (Sim & Wright, 2005). When assessing reliability of performance in a skill-based test, it is recommended that outcomes are evaluated and monitored for each individual athlete due to the variability that exists between athletes in skill performance during game-play (Robertson, et al., 2014). Despite the evidence regarding the importance of examining the validity and reliability of a newly-designed assessment, these data are limited for shooting protocols administered in basketball to date.

2.3 Jump Shooting Assessments in Basketball

Jump shooting accuracy has been previously assessed in basketball; however, a gold-standard assessment remains absent from the sport with current assessments lacking either the required validity or reliability outcomes to support their application. Furthermore, current jump shooting assessments assess two- and three-point shots in

isolation. Inter-subject variability in testing conditions and ambiguous information detailing the testing protocols presented in the current literature are other limitations of existing jump shooting assessments.

2.3.1 Stationary Two- and Three-Point Shooting Tests

A battery of jump shooting accuracy tests were developed by Pojskic, Separovic, and Uzicanin (2011), as outlined in Table 2, where athletes attempted two shots from five different locations without a time limit across three repeated trials with a 3-minute rest between trials. In the two-point shooting test, shots were attempted from both corners and wings in addition to a location slightly above the free-throw line away from the basket. In the three-point shooting test, athletes attempted shots from both corners, both wings and at the top of the three-point line. Athletes received one point for each successful shot attempt (Pojskic, Separovic, & Uzicanin, 2011). The distance-accuracy trade-off was evident with superior shooting accuracy demonstrated from closer distances. Findings revealed shooting accuracy was superior across the three trials of the two-point jump shooting assessment (5.82 ± 1.64) compared to the three-point assessment (4.25 ± 1.81) (Pojskic, et al., 2011). Both the two- and three-point shooting assessments developed by Pojskic et al. (2011) were also examined for relative reliability, indicated by ICC, with reliability in the three-point assessment (ICC = 0.85) slightly superior to that observed in the two-point assessment (ICC = 0.82). Absolute reliability was greater in Pojskic's two-point assessment (CV = 28.3%) compared to the three-point assessment (CV = 42.8%) highlighting a greater consistency in individual shooting accuracy from shorter distances (Pojskic, et al., 2011).

These tests developed by Pojskic et al. (2011) assessed shooting accuracy from different locations on the court; however, two- and three-point shots were assessed independently, which limits the representation of in-game shooting demands. Athletes

have shown to alternate shots from both distances throughout game-play rather than attempt consecutive shots from the same distance (Gomez, et al., 2017). Furthermore, ambiguity in the test description makes it unclear whether athletes should attempt both shots in succession at each location or attempt a single shot at each location before returning to the beginning of the test and repeating the protocol. Additionally, the rationale behind the inclusion of each shot location contained in both assessments was not discussed resulting in further ambiguity in test design.

Table 2.

Characteristics of examined jump shooting accuracy assessments in basketball.

Test Name	Reference	Demographic	Statistical Outcomes	Limitations
Stationary Two-Point	Pojskic et al., 2011	19.1 ± 3.1 yr, males, semi-professional	Points scored out of 10 = 5.82 ± 1.64, ICC and CV across three series (0.82, 28.3%)	Two-point shooting accuracy assessed in isolation
Stationary Three-Point	Pojskic et al., 2011	19.1 ± 3.1 yr, males, semi-professional	Points scored out of 10 = 4.25 ± 1.81, ICC and CV across three series (0.85, 42.8%)	Three-point shooting accuracy assessed in isolation
Combined Basketball Skills Test	Conte et al., 2018	22.8 ± 4.2 yr, males, semi-professional and recreational	Cohen's *d* = - 1.13 for total errors, - 1.14 for performance time, ICC and CV across twelve trials for total errors (0.83, 12.9%) and performance time (0.96, 2.0%)	Assessed multiple basketball skills simultaneously, only assessed two-point jump shots

Note: ICC = intraclass correlation coefficient, CV = coefficient of variation.

2.3.2 The Combined Basketball Skill Test

The CBST involves twelve repeated trials of a protocol containing dribbling, passing, and shooting with each trial intercepted by a 60-second rest. Each trial begins with athletes dribbling then performing a bounce pass towards a target, before grabbing a second basketball and performing two behind-the-back crossover dribbles, one with each hand. Athletes then perform either a two-point jump shot, lay-up, or reverse lay-up depending

on the visual stimulus shown. Performance was compared between playing levels with superior performance time (d = -1.14) and less total errors (d = -1.13) demonstrated by semi-professional athletes compared to recreational athletes (Conte, et al., 2018). In the CBST, ICC values ranged from 0.83 for total errors to 0.96 for performance time. Consistency in individual outcomes in the CBST were reported with a CV of 12.9% for total errors which lowered to 2.0% for performance time. While the CBST involves jump shooting, only shots from two-point distances are attempted throughout the test. Furthermore, a greater focus appears to be placed on other basketball skills such as passing, dribbling, and other shot types.

2.3.3 Remaining Jump Shooting Assessments in Basketball

The existing jump shooting tests that combine two- and three-point shots may be more representative of the shooting demands athletes experience within games; however, these assessments have not been validated or examined for test-retest reliability. The assessment developed by Kinc (2008) consists of jump shots across two- and three-point shooting distances while Okazaki and Rodacki (2012) instructed athletes to attempt 10 jump shots in a random fashion from close, intermediate, and long distances from the basket. The American Alliance for Health, Physical Education, Recreation, and Dance (AAHPERD) basketball test instructs athletes to attempt a minimum of one shot from five different locations in addition to a maximum of four lay-ups in a 60-second time-frame. However, variability is introduced between subjects in this test as athletes can choose the remaining locations after satisfying these basic conditions (Vernadakis, Antoniou, Zetou, & Kioumourtzoglou, 2004).

Meanwhile, the Spot Up Shooting, Off the Dribble Shooting, and On the Move Shooting Tests are administered in the NBA Testing Combine, an annual event where potential athletes undertake multiple physical and technical assessments. The Spot Up

Shooting Test consists of five uncontested shot attempts from various distances and locations; however, it is unclear whether all five shots should be performed at each location in succession and the exact location of each shot attempt is not explicably defined (Thakur & Mahesh, 2016). The Off the Dribble Shooting Test contains 18 jump shots from three different areas on the court with each shot attempted off the dribble. Athletes move between various locations attempting jump shots after receiving a pass from a designated feeder during the On the Move Shooting Test (Thakur & Mahesh, 2016). Inconsistencies are introduced to this assessment because each pass attempt cannot be precisely replicated across test trials. While these assessments evaluate shooting accuracy from a range of shooting locations and distances, the lack of validation raises questions about the ability of each test to measure the intended outcome while the lack of test-retest reliability raises question about the consistency of measuring the intended outcome .

The literature highlights the influence of jump shooting in basketball with this skill utilised the most out of any shot type during game-play (Erculj & Strumbelj, 2015). Furthermore, a team's winning probability increases when superior shooting accuracy is displayed from two- and three-point distances compared to their opponent (Özmen, 2016). Despite the clear importance of the jump shooting skill, a gold-standard jump shooting accuracy protocol is absent from basketball practice. Validity and reliability are identified as two important measurement properties for a skill test (Robertson, et al., 2014); however, current assessments examining both of these properties do not assess shooting performance from two- and three-point distances in combination, deviating from the shooting demands experienced during game-play (Gomez, et al., 2017). Consequently, a newly-established assessment tool, the BJSAT, has been designed to assess jump shooting accuracy from various court locations and distances while alternating between two- and three-point shots. The BJSAT aims to become a reproducible assessment tool that can be utilised by various basketball athlete populations

regardless of the differences in game regulations across competitions; however, before utilisation in the field, the BJSAT needs to be examined for acceptable validity and reliability outcomes.

Chapter Three: Operation of the Basketball Jump Shooting Accuracy Test: Intra- and Inter-Rater Reliability of Scoring Procedures and Floor and Ceiling Effects for Test Performance

3.1 Chapter Overview

This chapter is currently under review for consideration to be published in the International Journal of Sports Science and Coaching . The structure of the chapter therefore abides by the guidelines outlined by this journal. This chapter refers to findings from chapter four. The chapter discusses the development of the BJSAT, a skill assessment which evaluates the jump shooting accuracy of basketball athletes. Additionally, the chapter examines two fundamental technical components of the assessment; intra- and inter-rater reliability. The opening section (Section 3.2) introduces the skill of jump shooting and discusses existing jump shooting assessments including their limitations, which the BJSAT aims to address. Section 3.3 describes how the BJSAT was developed before outlining the testing procedures undertaken. The main findings of the chapter are contained in Section 3.4 while these outcomes are discussed in Section 3.5 and are compared to those observed in skill assessments performed in other sports. Section 3.6 summarises the findings of the chapter while section 3.7 describes what the chapter adds to the current literature.

3.2 Introduction

Basketball is a court-based sport that requires athletes to repeatedly execute technical skills in combination with other movements (Montgomery, Pyne, & Minahan, 2010). Shooting is one such skill, with the jump shot the predominant shot type in basketball. In fact, jump shots accounted for 67% of all shots attempted in the 2014-15 National Basketball Association (NBA) season, demonstrating it is readily executed during high-level basketball competition (Erculj & Strumbelj, 2015). Jump shooting involves a two-handed shot executed while jumping from two legs and directly influences team success in basketball. In this regard, superior two- and three-point field goal percentage increases a team's probability of winning (Özmen, 2016). It is therefore important for basketball practitioners to have access to court-based tests that effectively assess jump shooting performance.

To date, few assessments have been developed evaluating shooting performance from two- and three-point distances in combination; providing limited options for basketball practitioners to assess shooting ability across various game-relevant distances in a single test. Existing assessments either contain too few shots across two- and three-point locations (Okazaki & Rodacki, 2012) or possess ambiguous instructions of the assessment protocols regarding the number of jump shot attempts required at each location (Kinc, 2008), which may diminish reproducibility of testing in practice. In response to these limitations of existing tests, the authors recently developed the Basketball Jump Shooting Accuracy Test (BJSAT) and examined for validity and reliability outcomes.

The validity and reliability of the BJSAT has been supported with the test demonstrating a significant, *large* difference ($d = 0.99$, $p < 0.01$) between two- and three-point shots with superior accuracy demonstrated from two-point distance (Boddington, Cripps, Scanlan, & Spiteri, 2019). This finding supports the content validity of the BJSAT

and demonstrates the assessment elicits similar differences in shooting accuracy relative to distance from the basket compared to those observed in game situations given accuracy for two-point shots is superior to accuracy for three-point shots during game-play (Ibáñez, et al., 2008; Sampaio, et al., 2004). Relative reliability across four trials of the BJSAT was rated as *moderate* (ICC = 0.71, p <0.01) demonstrating sufficient reliability of the BJSAT when using the average of repeated scores, while absolute reliability for CV measures was above the accepted benchmark (CV = 16.2%) (Boddington, et al., 2019). A slightly larger CV is not uncommon due to the inconsistencies of skill accuracy throughout competition where basketball athletes can experience periods of a game with high shooting accuracy followed by periods of poor shooting accuracy (Zhang, et al., 2017). Furthermore, the CV exhibited by the BJSAT is superior than other skill-based sports tests presented in the literature (Robertson, Burnett, Newton, & Knight, 2012; Russell, Benton, & Kingsley, 2010).

Although the BJSAT has demonstrated the ability to discriminate shooting accuracy between two- and three-point shots and has displayed test-retest reliability over multiple trials, the assessment has yet to be examined for important technical aspects of test operation, including intra- and inter-rater reliability and floor and ceiling effects. Intra-rater reliability appraises the reliability of a single assessor to score test performance on multiple occasions while inter-rater reliability refers to the level of agreement between two different assessors scoring the same test (Scholtes, et al., 2011). Meanwhile, floor and ceiling effects represent the number of athletes who occupied the lowest or highest score (or range of scores) possible (Robertson, et al., 2014). Development of a jump shooting assessment that replicates the variable shots attempted during games and possesses adequate intra- and inter-rater reliability is essential for practitioners to measure the efficacy of technically-focussed training interventions and quantify changes in performance. Consequently, it is necessary for skill tests to possess intra- and inter-rater

reliability because these aspects of test operation demonstrate that reliable scores are being awarded on each occasion the test is undertaken either by the same or different assessors.

Therefore, this study aims to: (1) determine the intra- and inter-rater reliability of the BJSAT and (2) determine whether floor and ceiling effects are encountered in performance during the BJSAT.

3.3 Methods

3.3.1 Subjects

Male (n = 12) and female (n = 19) semi-professional basketball athletes were recruited from two State Basketball League (SBL) Australian clubs (age: 22.3 ± 5.7 yr [range: 15-37 yr], playing experience: 13.5 ± 6.9 yr). All playing positions were represented in this observational study, including guards (n = 14), forwards (n = 14) and centers (n = 3). All athletes provided informed consent and were free from any injury or illness at the time of testing. All study procedures were approved by an Institutional Human Research Ethics Committee (approval number 017115F). Athletes were informed of the risks of the study before signing an approved informed consent form. Parental and/or guardian consent was obtained from athletes under the age of 18 years.

3.3.2 The Basketball Jump Shooting Accuracy Test

The BJSAT is an assessment that evaluates jump shooting accuracy from game-specific court locations combining two- and three-point shot distances. This configuration better replicates in-game shooting patterns compared to existing assessments that involve successive shot attempts from a single distance (Erculj & Supej, 2009; Pojskic, et al., 2011). The BJSAT was developed using publicly available datasets showing the most frequent court locations in which jump shots were attempted during basketball competition (Beshai, 2014). From these data, eight shot locations were chosen for

inclusion in the BJSAT with an equal number of shots attempted from two- and three-point distances (Figure 4). Four shot locations were replicated on the right and left sides of the court with athletes executing one jump shot from each location. The BJSAT is an assessment with pre-determined shooting locations and explicit instructions regarding testing protocols to enhance the reproducibility of the assessment by various populations.

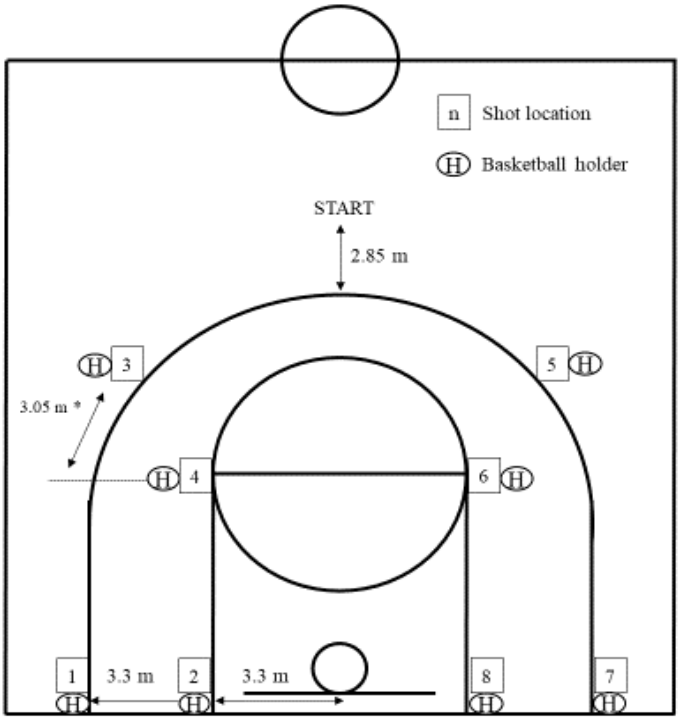

Figure 4. Layout of the Basketball Jump Shooting Accuracy Test.

*Mid-point between shot location three and extended free-throw line.

3.3.3 Testing Procedures

Testing was conducted on indoor, hardwood basketball courts prior to scheduled training sessions during the final week of a 4-month preseason phase. A portable, extendable camera recording at a sample rate of 60 Hz (Sony HDR-CX220; Eye Tower; SA, Australia) was positioned on the half-court line with full view of the basket and backboard during each BJSAT trial. A demonstration of the BJSAT was given to athletes prior to testing in addition to a 5-min general warm-up and 2-min shooting warm-up. Each athlete performed four trials of the BJSAT with 2 min of passive rest between trials. Four trials were completed to increase the number of shots attempted for reliability analyses. Furthermore, four trials of the BJSAT provides each athlete more shot attempts compared to the average demonstrated during game-play allowing shooting accuracy patterns to be revealed, given athletes can experience periods of both good and poor shooting accuracy intermittently (Zhang, et al., 2017). Athletes began each trial between the half-court line and three-point line (Figure 4). A holding apparatus standing 1 m above the ground delivered the basketballs (size 6 for female athletes and size 7 for male athletes; TF-1000 Legacy; Spalding; KY, United States of America and Wilson Solution, Wilson; NSW, Australia) to athletes at each shot location. All shots were attempted within a marked area (60 cm x 60 cm). If a jump shot was attempted with one or both feet outside of the marked area, athletes continued the trial; however immediate verbal instruction was given to ensure both feet were placed within the marked area for the remainder of the trial. Athletes were instructed to complete each trial of the BJSAT as fast as possible to ensure a pace consistent with game-play. Consistent verbal encouragement was given to ensure movement between shot locations was performed as fast as possible.

The BJSAT utilizes a scoring criteria with possible scores ranging from 0-3 for each shot (Table 1), a criteria with parameters similar to that utilized in other team sport skill assessments such as the Australian Football Kicking (AFK) test (Woods, et al.,

2015). Athletes were unaware of the scoring criteria to help ensure shooting technique did not change from the technique exhibited during training and game-play. Test performance was determined by summing the scores from each of the eight shot locations. For intra-rater reliability, one assessor scored the BJSAT live and again watching video footage across all trials for all athletes with 9-12 months separating scoring occasions to minimize retention of performances by the assessor. For inter-rater reliability, two assessors watched the same video footage separately and scored the BJSAT across all trials for all athletes. The assessors were aware of the testing and scoring protocols before scoring the assessment and both assessors had prior experience in evaluating skill assessments in sport. Assessors were not permitted to pause or re-watch video footage at any time to mimic a live assessment. Two assessors scored the BJSAT, with only one assessor being present in-person at each testing session. The assessor stood between shot location three and five (Figure 4) underneath the camera to allow clear view of all shot locations. The assessor who was not present at testing sessions, assessed the BJSAT using video footage.

Table 3.

Scoring criteria for the Basketball Jump Shooting Accuracy Test.

Criteria	Score
Basketball travels through the basket without touching the rim or backboard.	3
Basketball makes contact with the rim or backboard before travelling through the basket.	2
Basketball makes contact with the rim or backboard but does not travel through the basket.	1
Basketball does not make contact with the rim or backboard and does not travel through the basket.	0

3.3.4 Statistical Analyses

Descriptive statistics (mean ± standard deviations) were calculated for intra- and inter-rater reliability across all trials with an average reported for each type of reliability. Descriptive statistics were calculated to describe performance during the BJSAT for each method of scoring. Agreement between scores for intra- and inter-rater reliability analyses was determined using Cohen's kappa (κ), a statistic which indicates the level of agreement beyond chance (Sim & Wright, 2005). The following criteria were used to classify outcomes: *poor*, <0.20; *fair*, 0.21-0.40; *moderate*, 0.41-0.60; *substantial*, 0.61-0.80; and *almost perfect*, >0.80 (Yore et al., 2007). Floor and ceiling effects for intra- and inter-rater reliability were also examined by categorizing BJSAT scores into quartiles (e.g. scores of 0-6 were placed in the first quartile) and calculating the proportion of scores in each quartile for each trial. . Each of the four quartiles were defined as follows; quartile 1, 0-6; quartile 2, 7-12; quartile 3, 13-18; quartile 4, 19-24. This effect was examined because of the importance in identifying whether scores group at either the lowest or highest possible ranges when developing scored testing protocols. A grouping of scores at either end indicates the test is not suitable for the population assessed. Statistical analyses were undertaken using Statistical Package for Social Sciences (SPSS) software (v 25.0; IBM Corp., Armonk, NY, USA) with significance set at $p \leq 0.05$.

3.4 Results

Mean ± standard deviation BJSAT scores and reliability statistics are shown in Table 4. Intra-rater reliability was rated as *almost perfect* while inter-rater reliability was rated as *substantial*. Floor and ceiling effects are illustrated in Figure 5 for intra-rater reliability and Figure 6 for inter-rater reliability. As demonstrated, 98% of intra-rater reliability and 97% of inter-rater reliability scores were grouped in the second and third quartiles across all trials where BJSAT scores ranged from 7 to 18 for a single trial. Resultingly, 2% of intra-rater reliability and 3% of inter-rater reliability scores were allocated to quartile four where BJSAT scores ranged from 19 to 24 for a single trial. Meanwhile, no athletes were allocated to quartile one for any of the intra- and inter-rater reliability trials where BJSAT scores ranged from 0 to 6 for a single trial.

Table 4.

Intra- and inter-rater reliability statistics and floor and ceiling effects across four trials of the Basketball Jump Shooting Accuracy Test.

Reliability approach	**n**	**Mean ± SD**	**Reliability statistics**	
			κ (95% CI)	*p*
Intra-rater Reliability				
Intra-rater (live)	31	12.6 ± 2.5	0.85 (0.82-0.88)	<0.01
Intra-rater (video)	31	13.1 ± 2.8		
Inter-rater Reliability				
Inter-rater (assessor 1)	31	12.3 ± 2.5	0.70 (0.67-0.73)	<0.01
Inter-rater (assessor 2)	31	13.5 ± 2.9		

Note: SD = standard deviation; κ = Cohen's kappa; CI = confidence intervals.

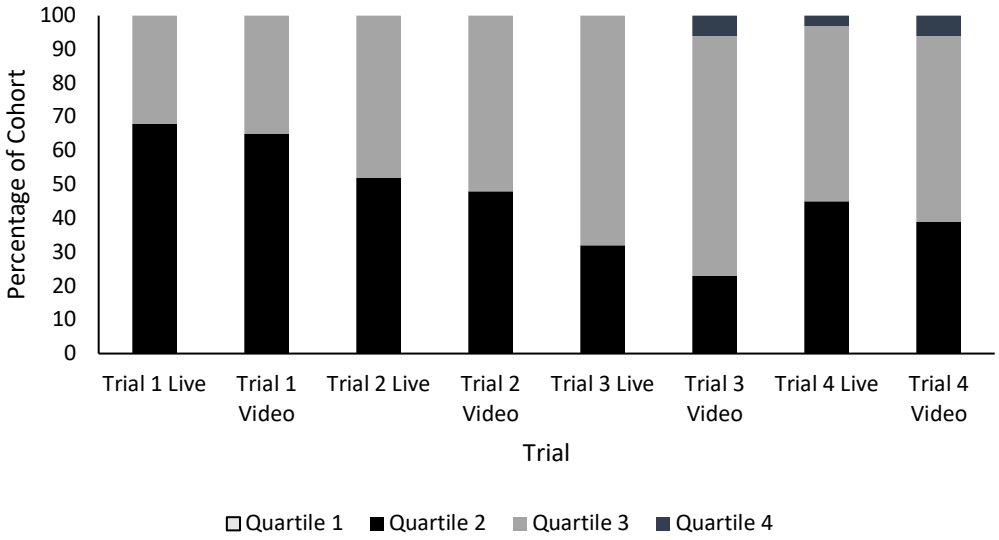

Figure 5. Intra-rater reliability BJSAT score by quartile for each trial of the BJSAT.

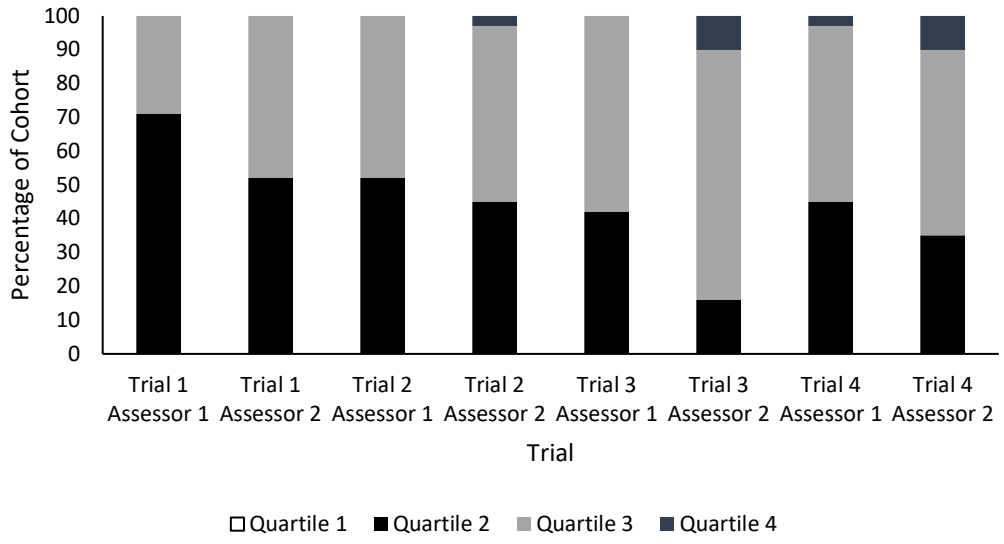

Figure 6. Inter-rater reliability BJSAT score by quartile for each trial of the BJSAT.

3.5 Discussion

The BJSAT is reflective of jump shooting demands during game-play as it involves alternating shots from two- and three-point distances, commonly executed in basketball game-play (Beshai, 2014). During game-play, successive jump shots are rarely attempted from the same distance, with shots instead attempted ad-hoc from a range of locations

and distances (Gomez, et al., 2017). Given the scoring criteria utilized in the BJSAT is subjective according to assessor interpretations, the scoring process should possess acceptable intra- and inter-rater reliability for consistent use in practice. Intra-rater reliability is recognized as an important measurement property indicating the quality of an assessment (Scholtes, et al., 2011). For intra-rater reliability, the BJSAT rated as *almost perfect* ($\kappa = 0.85$, $p < 0.01$). This outcome confirms a strong agreement between scores determined by the same assessor live in-person and watching captured video in real time. Consequently, performance during the BJSAT can be reliably scored by the same assessor across the season either live or following the test via video capture.

Inter-rater reliability for the BJSAT was *substantial* ($\kappa = 0.70$, $p < 0.01$), demonstrating a strong agreement between the scores determined by two different assessors. This finding indicates that different assessors can be interchangeably used to reliably score the BJSAT. The inter-rater reliability of the BJSAT was similar to that reported for another skill-based test, the AFK test (Woods, et al., 2015). The AFK test examines field kicking accuracy in Australian football for three different kicking distances. Like the BJSAT, the AFK test utilizes a subjective scoring criteria with the assessment also demonstrating *substantial* inter-rater reliability ($\kappa = 0.80$) (Woods, et al., 2015). This finding for the BJSAT is important as subjective scoring procedures may limit inter-rater reliability, thereby restricting the broader application of the test in practice due to the necessity for the same assessor to score the test on each occasion. However, the present data indicate the subjective scoring system proposed for the BJSAT provides acceptable levels of inter-rater reliability supporting the use of interchangeable assessors when administering the test across the season.

Floor and ceiling effects provide further information about an assessment allowing for accurate reproduction (Robertson, et al., 2014). Floor and ceiling effects were absent suggesting the BJSAT is a suitable assessment for male and female semi-

professional basketball athletes. Detection of a floor effects indicate a test may be too difficult for the athletes being assessed, which may limit the test's ability to provide meaningful analysis of performance. Meanwhile, presence of ceiling effects indicate athletes could master the test relatively quickly, limiting the ability to track meaningful changes in performance longitudinally.

Despite the novelty of the present findings for reliable shooting assessment in basketball athletes, some limitations were encountered. First, due to a lack of reliable match statistics, shooting performance during the BJSAT and actual competition was not able to be correlated to indicate ecological validity. However, given the aim of this study focussed on reliability of the scoring procedures, future research is encouraged to examine the correlation between shooting performance during the BJSAT and competition. Second, the BJSAT contains shot attempts from pre-determined locations unlike shot attempts during game-play which are in response to various stimuli. The assessment was developed in this manner to allow for time-efficient skill testing protocols. Third, it should be acknowledged that the sample size recruited for this study was limited, however the demonstration of statistically significant outcomes infer the study was appropriately powered to detect any meaningful differences. Finally, shooting data from the NBA was utilized to determine the BJSAT shot locations, which may not be representative of common shot locations in competitions such as the SBL. However, detailed shooting location data similar to that provided for the NBA was not available for other basketball competitions including the SBL.

3.6 Conclusion

The BJSAT is a skill assessment that assesses shooting accuracy from authentic court locations that are commonly encountered during basketball game-play. The intra- and inter-rater reliability of the BJSAT were *almost perfect* and *substantial*, respectively. Therefore, basketball practitioners can monitor jump shooting performance of athletes

using the BJSAT with the knowledge that reliable scores can be determined either by the same assessor or different assessors when administered across different time-points during the season. Jump shooting accuracy of basketball athletes can therefore be reliably evaluated by assessors using the BJSAT for various functions including player monitoring, to assess the efficacy of technique-oriented interventions and for team selection. Additionally, floor and ceiling effects were absent in BJSAT performance demonstrating the assessment was suitable for semi-professional basketball athletes.

Chapter Four: The Validity and Reliability of the Basketball Jump Shooting Accuracy Test

4.1 Chapter Overview

This chapter was accepted for publication in the Journal of Sports Sciences in February 2019 and abides by the guidelines outlined by the journal. This chapter explores the validity and test-retest reliability of the BJSAT, two measurement properties important to investigate before an assessment is utilised in basketball practice. Section 4.2 introduces the game of basketball and the importance of jump shooting accuracy during game-play. This section also presents the types of validity and test-retest reliability examined and the applications of these measurement properties. Section 4.3 details the study participants and describes the testing procedures that were employed. This section also reports the scoring system developed and utilised in the BJSAT. The validity and test-retest reliability outcomes of the BJSAT are presented in Section 4.4. Section 4.5 discusses key findings and provides comparisons to existing jump shooting assessments in basketball and skill tests in other sports. The practical applications that resulted from the validity and test-retest reliability outcomes of the BJSAT are presented in Section 4.6 and the key findings of the chapter are summarised in Section 4.7.

4.2 Introduction

Basketball requires athletes to execute a diverse range of physical and technical tasks during game-play (Abdelkrim, Chaouachi, et al., 2010; Scanlan, Dascombe, Reaburn, et al., 2012). Athletes frequently perform passing, dribbling and shooting manoeuvres during repeated, high-intensity and low-intensity running bouts (Read, et al., 2014). Shooting in particular is fundamental to offensive performance and strongly influences the outcome of basketball games. In this regard, winning probability increases when a team demonstrates superior accuracy from two- and three-point shooting distance compared to the opposing team (Ibáñez, et al., 2008; Lorenzo, et al., 2010; Melnick, 2001; Özmen, 2016). There are a variety of shot types performed in basketball such as the lay-up, dunk and jump shot; however, the jump shot is recognised as the most common shot executed, accounting for 67% of all shot attempts in the 2014-15 National Basketball Association (NBA) regular season (Erculj & Strumbelj, 2015). Despite the importance of jump shooting performance to team success, there are few valid and reliable assessments to assess jump shooting accuracy in basketball athletes.

Existing assessments examine jump shooting accuracy however important testing considerations are lacking. When designing a skill test in sport, a key consideration is replicating the conditions in which the skill is commonly performed while also ensuring these conditions remain consistent for each athlete. For example, the AFK test assesses field kicking accuracy with temporal constraints placed on athletes from distances commonly disposed from during a game (Woods, et al., 2015). Inter-subject variability in test conditions has been observed in existing jump shooting tests due to underpinning methodological limitations. For instance, during the On the Move Shooting Test and 60-second dynamic two-point and three-point shooting tests, athletes receive a chest pass before each shot attempt, which introduces inconsistencies to the shooting conditions given each pass attempt cannot be precisely replicated across test trials (Pojskić,

Šeparović, Muratović, & Užičanin, 2014; Thakur & Mahesh, 2016). Furthermore, the AAHPERD basketball test instructs athletes to attempt a minimum of one shot from five different locations in addition to a maximum of four lay-ups in a 60-second time frame. Variability is introduced between subjects in this test as athletes can choose the remaining locations after satisfying these basic conditions (Vernadakis, et al., 2004). Another limitation of current jump shooting assessments in basketball is the ambiguous information detailing the testing protocols presented in the current literature, which weakens test reproducibility (Robertson, et al., 2014; Thakur & Mahesh, 2016). For example, the Spot Up Shooting Test instructs players to attempt five jump shots from different locations; however it is unclear whether all five shot attempts should be performed at each location in succession and the exact location of each jump shot is not explicably defined (Thakur & Mahesh, 2016). Meanwhile, the stationary two-point and three-point shooting tests assess accuracy from five different locations with each athlete attempting two shots from each location. However, it is unclear whether athletes attempt two shots in succession at each location or attempt a single shot at each location before returning to the beginning of the test and repeating the same protocol (Pojskić, et al., 2014). Moreover, while the majority of jump shooting assessments evaluate two- and three-point shots in isolation (Erculj & Supej, 2009; Pojskic, et al., 2011; Slawinski et al., 2018), the existing tests that combine two- and three-point shots have not been validated (Kinc, 2008; Okazaki & Rodacki, 2012; Thakur & Mahesh, 2016).

A valid and reliable jump shooting assessment can have wide-ranging applications in basketball. Skill accuracy assessments can be utilised either on their own or as part of a multi-dimensional assessment included in the talent identification process (Robertson, et al., 2014) and to assist with skill development in basketball athletes. Individual limitations in jump shooting technique can be identified for each athlete which can help in the development of specific skill-enhancing strategies (Robertson, et al., 2014). A

simple, repeatable skill assessment can also allow for progress in skill performance to be monitored which helps to assess the effectiveness of implemented training interventions (Sunderland, et al., 2006).

Before utilisation in the field, skill assessments should first be examined for validity and reliability. Validity refers to the degree in which a test measures the skill in question. Specifically, content validity refers to the ability of a test to mimic particular actions of a sport, such as comparing test outcomes between shots of varying difficulty (Aandstad & Simon, 2013). Furthermore, construct validity can be assessed by comparing skill outcomes of athletes competing at varying playing levels with superior shooting accuracy expected to be possessed by athletes competing at the higher level (Sampaio, et al., 2004; Scanlan, Dascombe, & Reaburn, 2012). Meanwhile, determination of reliability across multiple trials indicates the consistency of an assessment to measure the outcome of interest (Robertson, et al., 2014). Relative reliability refers to the consistency of the position of individual scores relative to others in a group whereas absolute reliability simply concerns the consistency of scores by each individual (Weir, 2005). A common challenge when developing a skill test is balancing the trade-off between validity and reliability where consistent testing conditions are present for each athlete while also ensuring the assessment possesses valid characteristics similar to those seen during game-play. Maintaining a balance between both test features can be difficult but important to achieve.

The current limitations in shooting tests developed for application in basketball such as inter-subject variability in testing conditions, ambiguous information regarding testing protocols and assessing two- and three-point shooting accuracy in isolation has led to the development of the Basketball Jump Shooting Accuracy Test (BJSAT). The BJSAT is designed to evaluate jump shooting accuracy across game-specific court

locations in a replicable manner. Therefore, the aim of this study is to determine the content validity, construct validity, and reliability of the BJSAT.

4.3 Methods

4.3.1 Participants

Male (n = 18) and female (n = 23) semi-professional basketball athletes were recruited from two separate SBL clubs. Athletes were categorised as either SBL (n = 30, age: 22.7 ± 6.1 yr, playing experience: 14.2 ± 7.4 yr) or SBL Division I (n = 11, age: 20.6 ± 2.1 yr, playing experience: 11.4 ± 4.3 yr) based on the predominant competition played during the 2018 regular season. The SBL is the state-level basketball competition in Western Australia comprising of men's and women's competitions, while the SBL Division I is the competition directly below. Athletes competing in both competitions train together before being selected to play in either the SBL or SBL Division I each week. Selection in a particular competition can change on a weekly basis with some athletes playing games at both competition levels throughout the season while others are selected to play in one of the competitions for longer periods of time. All playing positions were represented among the cohort, including guards (males = 6, females = 13), forwards (males = 11, females = 7) and centres (males = 1, females = 3). All athletes provided informed consent, with athletes under the age of 18 providing written consent from their guardians. Athletes were free from any injury or illness that limited participation with those unable to participate instructed to notify the assessor prior to testing. The study protocol was approved by an Institutional Human Research Ethics Committee.

4.3.2 Basketball Jump Shooting Accuracy Test Development

The BJSAT was developed using shot location data derived from the 2013-14 NBA regular season which revealed the court locations where athletes attempted a high frequency of shots (Beshai, 2014). Though this data does not state the type of shots

attempted from these locations, it was expected that these were jump shots due to the distance of the locations from the basket chosen for inclusion in the BJSAT. From these data, 4x two-point and 4x three-point shot locations were included in the BJSAT with an equal number of shot attempts from the right and left side of the court. In total, the BJSAT consisted of 8 x jump shot attempts at pre-determined locations on the court. One jump shot was attempted from each of the eight shot locations in a predefined order (Figure 4). The shot order of the BJSAT ensured athletes were alternating between two- and three-point shooting distance and not performing consecutive jump shots from either distance throughout the test. This feature of the BJSAT more closely replicates in-game shooting patterns (Gomez, et al., 2017) compared to jump shooting assessments previously undertaken in basketball that involve successive shot attempts from the same shooting distance (Erculj & Supej, 2009; Pojskic, et al., 2011; Pojskic, Sisic, Separovic, & Sekulic, 2017).

4.3.3 Testing Procedures

Testing sessions were conducted on indoor, hardwood basketball courts prior to scheduled training sessions. Testing was undertaken during the final week of a 4-month pre-season phase before the opening regular season game. During this phase, athletes were undertaking two training sessions per week each two hours in duration. Training was predominantly skill-based and focussed on match-play. Prior to testing, all athletes were given a demonstration of the BJSAT and performed a 2-min shooting warm-up from the shot locations included in the BJSAT. Athletes were instructed to attempt four shots with an even spread from the left and right sides of the court and from two- and three-point distance. A standardised 10-min warm-up consisting of light shuttle runs, bilateral CMJs and dynamic stretching was also undertaken by all athletes. Each athlete completed four trials of the BJSAT with 2 min of passive rest between trials where athletes could walk around the other half of the court and recover before the next trial. If a jump shot

was performed in the incorrect order, athletes were advised to continue the assessment with verbal instruction ensuring the correct order was followed for the remainder of the trial. Athletes began each trial at the mid-point between the half-court line and three-point line (Figure 4). At each shot location, a holding apparatus standing at a height of 1 m was positioned to deliver basketball to the athletes. The male athletes used standard size 7 basketballs (Wilson Solution; Wilson; NSW; Australia) and the female athletes used standard size 6 basketballs (TF-1000 Legacy; Spalding; KY; United States of America) to align with game regulations. All shots were attempted with athletes placing both feet within a marked area at each shot location (60 cm x 60 cm). If an athlete attempted a jump shot with one or both feet outside the marked area, the athlete continued the trial; however verbal instruction was given immediately to ensure both feet were placed within the marked area for the remaining shot attempts. These approaches permitted standardised shooting conditions for all athletes.

Athletes were instructed to complete each trial of the BJSAT as fast as possible to replicate the intensity of jump shot attempts in games. When attempting jump shots in games, athletes commonly have little time due to defensive pressure. Athletes were instructed to not wait and observe the outcome of each shot attempt but instead sprint to the next shot location after attempting each shot. A time limit for each trial was not placed on the athletes; however consistent verbal encouragement was given during each trial to ensure athletes were moving as fast as possible between each shot location. Athletes took 28.1 ± 2.7 s to complete the BJSAT.

4.3.4 Basketball Jump Shooting Accuracy Test Scoring System

Four different scores could be awarded for each jump shot attempt in the BJSAT adapted from similar sill assessments in Australian football and basketball (Strand & Wilson, 1993; Woods, et al., 2015). For the BJSAT, scoring options ranged from 0-3 (Table 3).

Two assessors scored the BJSAT with one assessor present for the testing session undertaken at each respective club. Both assessors were made aware of the testing and scoring protocols before administering the test. Overall test performance for each trial was determined as the total score for each of the eight shots attempted. For example, if an athlete received a score of 2 points for each shot attempt, an overall score of 16 was recorded for that trial. Each athlete received a mean BJSAT score for each trial and for the four trials combined. Jump shooting accuracy could therefore be monitored for trends such as a trial order effect.

4.3.5 Statistical Analysis

Means and standard deviations were calculated for all BJSAT scores across each of the four trials separately. To evaluate content validity, a dependent t-test was performed to compare scores between two- and three-point shot attempts across all trials (Kinc, 2008). Construct validity of the BJSAT was assessed using an independent t-test to compare performance between athletes of different gender (males vs. females) and playing levels (SBL vs. SBL Division I) across all trials. Effect sizes (*d*) were calculated for each pairwise comparison based on the following classifications: *trivial* = 0-0.19, *small* = 0.20-0.49, *medium* = 0.50-0.79 and *large* = >0.80 (Cohen, 1992). The mean typical error (TE) and smallest worthwhile change (SWC) were calculated for the four trials combined. Four trials were conducted to examine the reliability of the BJSAT. Between-trial reliability of the BJSAT was assessed by determining relative reliability indicated by ICC and absolute reliability indicated by CV measures with 95% confidence intervals (CI). For all ICC calculations, a two-way mixed model was undertaken because of the suitability this model provides to research involving repeated measures. The following criteria were used to classify ICC outcomes: *poor* = <0.50, *moderate* = 0.51-0.75, *good* = 0.76-0.90 and *excellent* = >0.90. (Koo & Li, 2016). A CV <10% was taken as an acceptable benchmark (Atkinson & Nevill, 1998). Parametric assumptions of normality and homogeneity of

variance were assessed and confirmed prior to running inferential statistics. Statistical analyses were performed using SPSS software (v 25.0, IBM Corp., Armonk, NY, USA). Statistical significance was set at $p \leq 0.05$.

4.4 Results

4.4.1 Content and Construct Validity

Mean ± standard deviation scores during the BJSAT according to shot distance (two-point vs. three-point distance) and playing level (SBL vs. SBL Division I) for all trials combined are shown in Figures 7 and 8. There was a significant, *large* ($d = 0.99$, $p = < 0.01$) difference in BJSAT score between two- and three-point shots. There was a non-significant, *trivial* ($d = 0.17$, $p = 0.57$) difference in BJSAT score between gender. There was also a non-significant, *trivial* ($d = 0.15$, $p = 0.70$) difference in BJSAT score between playing levels. The mean TE of the BJSAT across all trials combined was 2.2 while the SWC was 1.6 (0.2) and 4.0 (0.5) respectively.

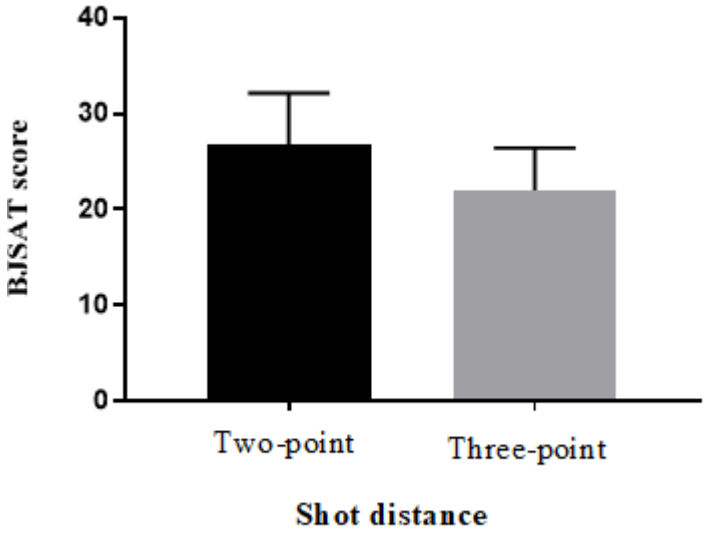

Figure 7. The mean ± standard deviation Basketball Jump Shooting Accuracy Test (BJSAT) score at different shot distances.

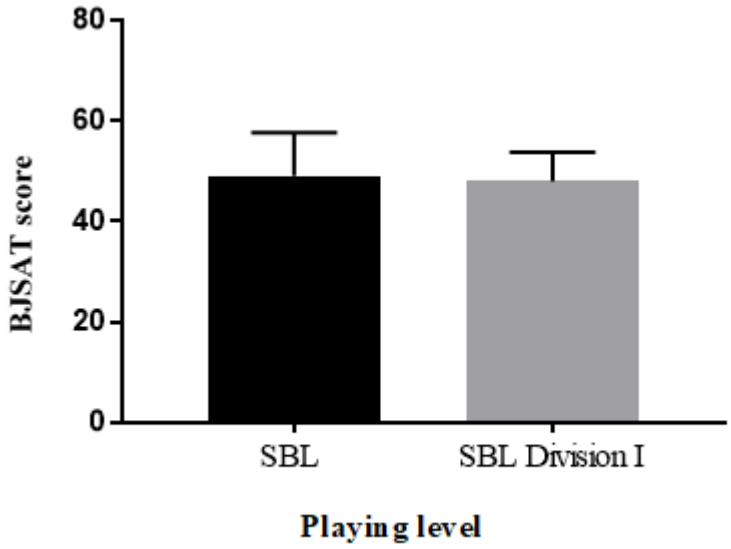

Figure 8. The mean ± standard deviation Basketball Jump Shooting Accuracy Test (BJSAT) score for athletes competing at State Basketball League (SBL) and SBL Division I levels.

4.4.2 Reliability

Mean ± standard deviation, ICC, and CV with 95% CI for BJSAT score are presented in Table 5. Analysis of all athletes across the four trials demonstrated *moderate* relative reliability (n = 41, ICC = 0.71, p < 0.01), which strengthened when only the SBL athletes were analysed (n = 30, ICC = 0.78, p < 0.01) and weakened when only the SBL Division I athletes were assessed (n = 11, ICC = 0.31, p = 0.20). Absolute reliability was above the accepted benchmark for all athletes (CV = 16.2%), the SBL athletes (CV = 17.5%) and the SBL Division I athletes (CV = 12.1%). Males (n = 18, ICC = 0.72, p < 0.01) and females (n = 23, ICC = 0.73, p < 0.01) both demonstrated *moderate* relative reliability while absolute reliability was above the accepted benchmark for both males (CV = 16.9%) and females (CV = 15.8%). Two-point shooting accuracy demonstrated greater reliability (ICC = 0.68, p < 0.01, CV = 19.8%) compared to three-point shooting accuracy (ICC = 0.58, p < 0.01, CV = 20.0%).

Table 5.

The mean ± standard deviation score and reliability statistics across four trials of the Basketball Jump Shooting Accuracy Test (BJSAT), according to playing level and shooting distance.

Group	**n**	**BJSAT score**					**Reliability statistics**		
		Trial 1	*Trial 2*	*Trial 3*	*Trial 4*	*Total*	*ICC (95% CI)*	*p*	*CV%*
All Athletes	41	10.9 ± 2.6	12.7 ± 3.0	12.7 ± 2.5	12.5 ± 2.7	48.8 ± 7.9	0.71 (0.53-0.83)	<0.01*	16.2
SBL	30	10.9 ± 2.7	13.0 ± 3.1	12.6 ± 2.7	12.6 ± 2.6	49.1 ± 8.6	0.78 (0.61-0.88)	<0.01*	17.5
SBL Division I	11	11.0 ± 2.1	11.8 ± 2.7	12.8 ± 2.0	12.4 ± 3.1	48.0 ± 5.8	0.31 (-0.72-0.79)	0.20	12.1
Shot distance									
Two-point	41	6.0 ± 1.6	6.9 ± 2.0	6.9 ± 2.1	7.0 ± 1.7	26.8 ± 5.3	0.68 (0.48-0.81)	<0.01*	19.8
Three-point	41	4.9 ± 1.7	5.8 ± 1.7	5.8 ± 1.4	5.7 ± 1.8	22.0 ± 4.4	0.58 (0.33-0.76)	<0.01*	20.0

Note: SBL = State Basketball League; ICC = intraclass correlation coefficient; CI = confidence intervals; CV = coefficient of variation; * indicates statistical significance.

4.5 Discussion

This study presents the development of a jump shooting accuracy assessment, which was deemed to possess adequate content validity. When evaluating the content validity of the BJSAT, athletes scored significantly better in two-point shot attempts compared to three-point attempts (d = 0.99, $p < 0.01$). The BJSAT was sensitive to the distance accuracy trade-off demonstrated in previous shooting tests with accuracy greater in two-point shots compared to three-point shot attempts, mimicking a pattern observed during game-play where two-point shooting accuracy is often superior to three-point accuracy (Kinc, 2008; Okazaki & Rodacki, 2012; Özmen, 2016). Previous evidence demonstrates basketball athletes tend to be less accurate from greater shooting distances due to an increase in velocity and release angle on the basketball and decline in release height (Okazaki & Rodacki, 2012). Athletes adopt these movement strategies when shooting from longer distances leading to greater instability on the basketball and consequently detrimental shooting performance outcomes (Okazaki & Rodacki, 2012). Our findings confirm a *large* difference exists between the shooting accuracy of athletes from two-point distances compared to three-point distances during the BJSAT highlighting the assessment's ability to detect differences in shooting accuracy between shots of varying difficulty while replicating in-game shooting demands. The BJSAT replicates these demands because jump shot attempts throughout the test alternate between shooting location and distance. During basketball game-play, jump shots are sparsely attempted from the same location or distance repeatedly with statistics showing shots are attempted from a spread of locations and distances (Gomez, et al., 2017). The BJSAT is one of the few current assessments that combine shot attempts from two- and three-point distance (Kinc, 2008; Okazaki & Rodacki, 2012; Thakur & Mahesh, 2016), however unlike these existing assessments, shooting performance from two- and three-point distance in the BJSAT has been validated.

Construct validity provides insight into the ability of an assessment to discriminate between different groups of athletes. A non-significant, *trivial* difference was observed between gender (d = 0.17, p = 0.57). Little difference in jump shooting accuracy was forecasted between male and female athletes because both genders were recruited from a state-level competition, testing was undertaken at the same point in the season and similar training programs were being undertaken at the time of testing. Interestingly, only a non-significant, *trivial* difference (d = 0.15, p = 0.70) was evident in BJSAT score between SBL and SBL Division I athletes. The low sensitivity of the BJSAT to differentiate between athletes of higher and lower playing levels may have been due to methodological limitations in athlete recruitment rather than an inability to discriminate between athletes possessing higher and lower shooting accuracy. The largest limitation in athlete recruitment was the similarity between playing levels because both groups of athletes undertook similar training programs, with many athletes competing at both levels throughout the season. A pre-determined number of athletes was not sought for each playing level and position, rather that each was represented by both genders. As all athletes participating in this study were recruited from two SBL teams, it is possible the poor sensitivity in differentiating between the SBL and SBL Division I athletes may have been due to the samples demonstrating homogenous skill outcomes. Rather it is plausible other attributes differentiate playing level in these athletes given higher-level basketball competition often necessitates superior physical (e.g. jump power) (Abdelkrim, Chaouachi, et al., 2010), technical (e.g. dribbling speed) (Torres-Unda et al., 2013) and tactical (e.g. number of positioning movements) (Abdelkrim, Castagna, El Fazaa, & El Ati, 2010) attributes. Future research should further explore the discriminatory capacity of the BJSAT to differentiate shooting accuracy between athletes from playing levels who possess notable differences in shooting ability such as national and state competitions.

Skill tests should possess acceptable validity as well as adequate reliability before being adopted in practice. The BJSAT was shown to possess *moderate* relative reliability, comparable to previously reported shooting tests such as the two- (ICC = 0.82) and three-point (ICC = 0.85) tests developed by Pojskic et al. (2011). While the BJSAT possesses weaker ICC than the tests developed by Pojskic et al. (2011), tests developed previously exclusively examined only two- or three-point shots, whereas the BJSAT requires athletes to execute shots from both distances in combination. The variability in shooting distance and location in the BJSAT conceivably would reduce the relative reliability observed. However it is this variability in shooting distance and location that makes the BJSAT more representative of in-game shooting demands because shots are attempted from a range of distances and locations during games (Gomez, et al., 2017). Research has also examined novel skill assessments in other sports, reporting either similar or lower relative reliability than observed in our study. For instance, the Nine-Ball Skills Test is used in golf and assesses the ability to land nine different shot types at a certain location, demonstrating an ICC of 0.67 (Robertson, et al., 2012). Meanwhile soccer passing, shooting and dribbling tests assessing skill precision across two separate trials revealed ICC ranging from 0.38-0.77 for different skills (Russell, et al., 2010). Relative reliability of the BJSAT were shown to be comparable with tests in other sports and slightly below those reported in basketball due to the modest variability across the repeated trials when all athletes were evaluated. There was evidence of a trial order effect with accuracy scores improving and stabilising across the first three trials of the BJSAT (Table 5). Practitioners therefore are encouraged to administer up to three trials of the BJSAT to habituate athletes with the shooting locations and order of the test. Undertaking a longer familiarisation of the BJSAT or shooting warm-up may also help habituate athletes sooner with the BJSAT. Novel assessment conditions and pre-planned shooting locations may have influenced the

shooting accuracy of athletes during the initial trial, thereby allowing a familiarisation exposure.

Compared to previous two- (CV = 28.3%) and three-point (CV = 42.8%) assessments in basketball, the BJSAT displayed superior absolute reliability (CV = 16.2%); however these remained above the accepted benchmark due to greater than normal variation from the mean accuracy scores across each of the four trials (Atkinson & Nevill, 1998). The BJSAT displayed comparable absolute reliability to skill assessments developed in other sports including golf (CV = 27.5%) (Robertson, et al., 2012) and soccer (CV = 4.6-23.5%) (Russell, et al., 2010). It is natural for skill assessments to demonstrate larger CV as this reflects technical performance within sport as superior athletes often demonstrate inconsistencies with skill accuracy throughout competition, such as inconsistencies in jump shooting accuracy between basketball games (Zhang, et al., 2017).

The findings support the use of the BJSAT in practice, however our study was subject to some limitations. First, each athlete on a basketball team does not attempt the same amount of jump shots each game with shot attempts influenced by factors such as playing position (Zhang, et al., 2017). Additionally, the shots were attempted across a short duration, which is not commonly experienced during basketball game-play; however was necessary due to the practical requirements for efficient testing procedures. Second, the shot locations included in the BJSAT were derived from NBA data which may not be reflective of common shot locations in other competitions such as the SBL. Shooting location data used for the BJSAT was taken from the NBA given these data were not accessible from other competitions, including the SBL. Third, the assessment is pre-planned whereas shots are attempted in response to various stimuli during game-play. Therefore, performance in the BJSAT may not be reflective of all in-game scenarios encountered by athletes, such as shooting with the presence of a defender or in response

to a particular game situation. The BJSAT is pre-planned with a determined shot order to ensure consistent testing protocols for all athletes. Fourth, shooting performance in the BJSAT was not correlated with 2018 field goal percentage due to a lack of reliable match performance statistics. These statistics presented an athlete's field goal and three-point percentage therefore not breaking the data by shot types. Consequently, jump shooting accuracy of an athlete could not be identified during games and therefore not correlated with BJSAT performance. As a result, it is encouraged that future research examines the correlation between BJSAT and within competition shooting performance. Finally, our findings are indicative of male and female state-level basketball athletes and therefore may not be representative of other populations. Consequently, further research is encouraged confirming the validity and reliability of the BJSAT in athletes from teams competing at different playing levels and age groups. Further research is also recommended examining the effects of gender on shooting performance in the BJSAT in different playing levels.

4.6 Practical Applications

The BJSAT may be used by basketball coaches, strength and conditioning staff, sport scientists, and athletes as a tool to quantify and track intra-individual jump shooting accuracy. The BJSAT was unable to discriminate between gender and playing level however was shown to be sensitive to shooting distance and reliable from the court locations and distances contained in the assessment, as shown by the *moderate* relative reliability outcomes. Absolute reliability of the BJSAT however was above the accepted benchmark while the mean TE was 2.2 across all four trials and the SWC was 1.6 (0.2) and 4.0 (0.5), therefore practitioners are encouraged to monitor the position of each athlete's score relative to other members of the team. Practitioners are also encouraged to utilise the BJSAT to evaluate jump shooting accuracy in playing levels who possess more

pronounced differences in shooting ability to observe whether the assessment can discriminate in this manner. These findings illustrate the BJSAT may be utilised in monitoring shooting accuracy from game specific shooting locations and distances. Furthermore, the BJSAT can assist practitioners in reliably assessing shooting accuracy across different points in time such as for monitoring rehabilitation progress, assessing skill technique interventions and assisting in team selection.

4.7 Conclusion

The BJSAT is a valid jump shooting accuracy test that is sensitive to shooting distance with athletes demonstrating superior accuracy from two-point compared to three-point attempts. Meanwhile, the BJSAT detected *trivial* differences in jump shooting accuracy of athletes competing at different, but relatively homogeneous, playing levels describing the construct validity of the assessment. The BJSAT demonstrated acceptable relative reliability across multiple trials in basketball athletes of varying playing levels. As a result, practitioners can utilise the BJSAT in monitoring jump shooting accuracy at progressive stages of a season for various purposes such as evaluating skill technique or rehabilitation interventions. Absolute reliability of the BJSAT however was above the accepted benchmark therefore practitioners are encouraged to monitor shooting accuracy performance of each athlete relative to other team members across a period of time.

Chapter Five: Discussion and Conclusion

5.1 Introduction

Jump shooting is an influential skill performed during basketball game-play accounting for 67% of all shot attempts (Erculj & Strumbelj, 2015). Furthermore, superior jump shooting accuracy from two- and three-point distances increases a team's winning probability, further highlighting the importance of the skill. Despite the clear influence of jump shooting performance to team success, there is a lack of valid and reliable assessments that currently evaluate jump shooting accuracy from two- and three-point distances. Many existing assessments instead assess shooting performance from either distance in isolation (Conte, et al., 2018; Erculj & Supej, 2009; Pojskic, et al., 2011), which does not reflect the shooting demands encountered by athletes during game-play as the literature shows shots are alternated between two- and three-point distances (Gomez, et al., 2017).

5.2 Chapter Summary and Conclusion

5.2.1 Chapter Three – Development of the Basketball Jump Shooting Accuracy Test: Intra- and Inter-Rater Reliability

Chapter three of the thesis discussed the development of the newly-established BJSAT for application in basketball in addition to examining the intra- and inter-rater reliability of the assessment. The BJSAT demonstrated *almost perfect* intra-rater reliability showing a strong agreement between scores given by the same assessor live and while watching video footage. This finding reveals that scores awarded by the assessor live during the BJSAT are predominantly similar to those awarded while watching video footage confirming the suitability of the scoring criteria utilised in the BJSAT. Inter-rater reliability was rated as *substantial* demonstrating different assessors can reliably score the BJSAT. Given the same assessor may not be available each time the assessment is

undertaken, it is important that reliable scores can be determined by different assessors. Floor and ceiling effects meanwhile were absent from the BJSAT with 98% of intra-rater reliability and 97% of inter-reliability scores grouped in the second and third quartiles. This finding shows the BJSAT was suitable for the athletes assessed as the assessment was not too difficult to undertake or too easy to master.

5.2.2 Chapter Four – The Validity and Reliability of the Basketball Jump Shooting Accuracy Test

Chapter four examined the content validity, construct validity, and test-retest reliability of the BJSAT. The BJSAT displayed a significant, *large* ($d = 0.99$, $p < 0.01$) difference between shots from two- and three-point distances. Jump shooting accuracy was superior in two-point shots compared to shots from the longer three-point distance, a similar trend exhibited by basketball athletes during game-play (Özmen, 2016; Zhang, et al., 2017). Meanwhile, the BJSAT exhibited non-significant, *trivial* differences between gender ($d = 0.17$, $p = 0.57$) and playing level ($d = 0.15$, $p = 0.70$). Minimal differences were shown in the shooting accuracy of male and female athletes which may have been due to both cohorts being recruited from the same competition level and testing being conducted at the same point of the season. The inability of the BJSAT to differentiate between playing levels may have been due to limitations in athlete recruitment rather than an inability of the BJSAT to discriminate between playing levels. Athletes recruited from both playing levels were undertaking similar training programs and many athletes were competing at both levels throughout the course of the season highlighting the homogeneity across groups.

Relative reliability across four trials of the BJSAT was rated as *moderate* for all athletes (ICC = 0.71, $p < 0.01$), demonstrating sufficient reliability of the BJSAT when using the average of repeated scores. Absolute reliability was above the accepted

benchmark for CV measures (CV = 16.2%), a common outcome in skill assessments due to the inconsistencies in skill accuracy throughout game-play (Zhang, et al., 2017). Greater test-retest reliability was demonstrated in two-point shots (ICC = 0.68, $p < 0.01$, CV = 19.8%) compared to three-point shots (ICC = 0.58, $p < 0.01$, CV = 20.0%) which strengthens the evidence showing the BJSAT exhibits similar shooting trends to those seen during game-play where two-point accuracy is superior than three-point accuracy (Özmen, 2016).

5.3 Implications and Practical Recommendations

5.3.1 Monitoring Jump Shooting Accuracy

The findings from this thesis demonstrate the BJSAT can be utilised to monitor jump shooting accuracy from game-specific court locations and distances. The *moderate* relative reliability (ICC = 0.71, $p < 0.01$) when using the average of repeated scores suggests the assessment can be reliably undertaken at various stages of the season to longitudinally monitor the progress of shooting accuracy of athletes compared to others in a team, such as athletes in the same playing position. Practitioners can monitor and analyse the shooting accuracy of each team member, detecting potential differences in shooting performance from particular locations, sides of the court, or shooting distance. Specific interventions may then be introduced in response to the shooting accuracy outcomes of each athlete.

5.3.2 Assessing the Efficacy of Interventions

The supported relative reliability demonstrate the BJSAT can be reliably utilised to assess the efficacy of interventions aimed at skill improvement or rehabilitation for example. Practitioners may implement specific interventions in athletes based on shooting accuracy performance during the BJSAT or during an athlete's rehabilitation period to track progress for return to play.

5.3.3 Different Assessors Implementing the Basketball Jump Shooting Accuracy Test

Intra- and inter-rater reliability outcomes demonstrate performance during the BJSAT can be reliably assessed by one or multiple assessors providing teams with the flexibility of having different assessors throughout the season while maintaining reliable scores. Throughout the course of a season, the same assessor may not be available each time the BJSAT is conducted, therefore it is important to know that the assessment can be conducted with different assessors.

5.4 Limitations

In addition to the limitations identified in Chapter 1, some additional limitations were encountered as the study progressed. These limitations include;

- Jump shooting accuracy performance in the BJSAT was not correlated with shooting performance during game-play due to a lack of reliable match shooting statistics. Available statistics did not disclose shooting accuracy of jump shots but instead grouped all shot types together for the recruited athletes making it difficult to correlate shooting accuracy in the BJSAT with shooting accuracy during game-play.
- The sample size could have been larger; however, the number of athletes in the entire cohort and each playing position was dependent on the availability of athletes during each testing session with some athletes not able to complete the testing due to injury or illness. However, the sample size used in this thesis was comparable to sample sizes observed in existing literature investigating the validity and reliability of newly developed skill tests in sport (Conte, et al., 2018; Sunderland, et al., 2006). Furthermore, the demonstration of significant findings suggest this study was appropriately powered to detect meaningful change (Hoenig & Heisey, 2001).

5.5 Future Research Directions

From the findings of this thesis, future research is encouraged to:

- Evaluate the relationship between the shooting accuracy of basketball athletes during the BJSAT and during game-play, described as criterion validity. This analysis would help demonstrate the ability of the BJSAT to produce similar shooting accuracy outcomes shown during competition which will further validate application of the BJSAT.
- Evaluate the BJSAT's ability to discriminate between playing levels with more pronounced technical and physical differences. Performance during the BJSAT should be quantified and compared between playing levels such as semi-professional and recreational or professional and semi-professional athletes in future work.
- Examine the BJSAT in competitions with different game regulations compared to those utilised in this study, such as in North America and Europe, in addition to youth competitions to compare findings from this study and to assess the utility of the BJSAT in other contexts.

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Appendices

Appendix A

Ethics Approval Letter

THE UNIVERSITY OF NOTRE DAME AUSTRALIA

19 Mouat Street (PO Box 1225) Fremantle WA 6959
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11 September 2017

Dr Tania Spiteri & Mr Brenton Boddington
School of Health Sciences
The University of Notre Dame, Australia
Fremantle Campus

Dear Tania and Brenton,

Reference Number: 017115F

Project title: "Effect of incremental neuromuscular fatigue on upper body kinematics and subsequent shooting accuracy in the basketball jump shot."

Your response to the conditions imposed by the university's Human Research Ethics Committee, has been reviewed and assessed as meeting all the requirements as outlined in the *National Statement on Ethical Conduct in Human Research* (2007, updated May 2014). I am pleased to advise that ethical clearance has been granted for this proposed study.

Other researchers identified as working on this project are:

Name	School/Centre	Role
Dr Ashley Cripps	School of Health Sciences	Co-Supervisor
Dr Aaron Scanlan	Central Queensland 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,

Dr Natalie Giles
Research Ethics Officer
Research Office

Cc: Prof Gerard Hoyne, SRC Chair, School of Health Sciences

Appendix B

Plain Language Statement

PARTICIPANT INFORMATION SHEET

The validity and reliability of a Novel Jump Shooting Accuracy Test

Dear participant,

You are invited to participate in the research project described below.

What is the project about?

The research project will investigate the validity and reliability of a newly developed jump shooting accuracy assessment. Therefore, basketball athletes of varying playing levels are required for comparison, hence the recruitment of SBL and SBL Division I basketball athletes such as yourself. Partaking in the study will contribute to improved knowledge in basketball including a better understanding of the novel jump shooting accuracy assessment and whether it is suitable for future use in basketball practice and literature. Participants may personally recognise changes to jump shooting technique and accuracy leading to improved performance through self-feedback and adaptation.

Who is undertaking the project?

This project is being conducted by Brenton Boddington and will form the basis for the degree of Master of Philosophy in Health Sciences at The University of Notre Dame Australia, under the supervision of Dr Tania Spiteri, Dr Ashley Cripps and Dr Aaron Scanlan.

What will I be asked to do?

If you consent to take part in this research study, it is important that you understand the purpose of the study and the procedures you will be asked to undergo and tasks you will be asked to complete. Please make sure that you ask any questions you may have, and that all your questions have been answered to your satisfaction before you agree to participate.

The testing session will be conducted at either Hale School or Cockburn Basketball Stadium. A warm-up and stretching routine will be administered at the beginning of each session. Participants will complete four trials of the novel jump shooting accuracy test with each trial consisting of one jump shot from eight different locations on the court (see Appendix). Participants will move from one location to the next at a high intensity, removing the basketball from a holder (standing at a height of 1 m) before performing the shot and moving to the next location. Accuracy scores will be awarded by a researcher on the day of testing, while a camera will be set up videotaping the novel jump shooting accuracy test to allow accuracy scores to be re-examined at a later time. Participants will be asked to provide approximately 15 minutes of their time with the testing session lasting 60 minutes in total.

Are there any risks associated with participating in this project?

Injury is a risk to the participants throughout the novel jump shooting accuracy test. A sufficient warm up, familiarisation of the assessment and a cool down will reduce the risk of injury. All researchers present will possess current senior first aid and CPR qualifications. If a serious injury were to occur a designated researcher will transport the participant to the nearest hospital and will stay with them until family members arrive. If the researchers believe it is a more appropriate course of action, an ambulance will be sought to the basketball centre.

What are the benefits of the research project?

Benefits for participants completing this study include gaining exposure to a novel shooting test that basketball athletes have not performed previously. By gaining this experience, participants can identify changes to shooting accuracy. This knowledge can lead to self-improvement where individuals identify and adjust their shooting technique to improve subsequent shooting performance. More generally, participants will be contributing to a research area that can provide practical applications to basketball teams and players around the world. By examining the validity and reliability of the novel jump shooting accuracy test, practitioners can confidently administer the test to gauge jump shooting accuracy in basketball athletes. Participants will also be able to receive feedback on their shooting accuracy compared to group averages of the players at their playing level.

What if I change my mind?

Participation in this study is completely voluntary. Even if you agree to participate, you can withdraw from the study at any time without discrimination or prejudice. If you withdraw, all information you have provided will not be used in the study.

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. An identification code will be given to each participant with only the student researcher and research supervisors having access to individual information which will remain confidential at all times by storing this information on a password protected laptop only accessible by the researchers. Published results of the study including those presented to the basketball organisation will be de-identified with results of each individual participant unknown. Once the study is completed, the data collected from you will be de-identified and stored securely in the School of Health Sciences 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 Masters of Philosophy thesis and published in peer review journals.

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 to the basketball organisation with results de-identified. Each participant will receive individualised feedback that can be compared to group averages. You can expect to receive this feedback approximately six months after data collection.

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

If you have any questions about this project please feel free to contact either myself (0447548886/ brenton.boddington1@my.nd.edu.au) or my primary supervisor Ashley Cripps (ashley.cripps@my.nd.edu.au). My supervisor and I 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 017115F). 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 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.

How do I sign up to participate?

If you are happy to participate, please sign both copies of the consent form, keep one for yourself and mail the other to me in the envelope provided.

Thank you for your time. You are able to keep this sheet for further reference.

Yours sincerely,

Brenton Boddington

Appendix C

Informed Consent

CONSENT FORM

The validity and reliability of the novel jump shooting accuracy test

- I agree to take part in this research project under the supervision of Brenton Boddington, Dr Tania Spiteri, Dr Ashley Cripps and Dr Aaron Scanlan.
- I have read the Information Sheet provided and been given a full explanation of the purpose of this study, the procedures involved and of what is expected of me.
- I understand that I will be asked to complete four trials of the novel jump shooting accuracy test, comprising of eight shot attempts per trial with two-minutes of rest in between each trial. Accuracy scores will be given on the day of testing by a researcher, while each rotation will also be video-taped to allow for accuracy scores to be re-examined at a later time.
- The researcher has answered all my questions and has explained possible problems that may arise as a result of my participation in this study.
- I understand that I may withdraw from participating in the project at any time without prejudice.
- I understand that all information provided by me is treated as confidential and will not be released by the researcher to a third party unless required to do so by law.
- I agree that any research data gathered for the study may be published provided my name or other identifying information is not disclosed.
- I understand that research data gathered may be used for future research but my name and other identifying information will be removed.
- I confirm that I have provided the Information Sheet concerning this research project to the above participant, explained what participating involves and have answered all questions asked of me.

Name of participant			
Signature of participant		Date	
Signature of Researcher		Date	