Cardiff School of Sport

DISSERTATION ASSESSMENT PROFORMA: Empirical [1]

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Dissertation title:	Discriminative power of valid game-related statistics in the National Basketball Association		
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Comments	Section
	Title and Abstract (5%) Title to include: A concise indication of the research question/problem. Abstract to include: A concise summary of the empirical study undertaken.
	Introduction and literature review (25%) To include: outline of context (theoretical/conceptual/applied) for the question; analysis of findings of previous related research including gaps in the literature and relevant contributions; logical flow to, and clear presentation of the research problem/ question; an indication of any research expectations, (i.e., hypotheses if applicable).
	Methods and Research Design (15%) To include: details of the research design and justification for the methods applied; participant details; comprehensive replicable protocol.
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	Discussion and Conclusions (30%) [2] To include: collation of information and ideas and evaluation of those ideas relative to the extant literature/concept/theory and research question/problem; adoption of a personal position on the study by linking and combining different elements of the data reported; discussion of the real-life impact of your research findings for coaches and/or practitioners (i.e. practical implications); discussion of the limitations and a critical reflection of the approach/process adopted; and indication of potential improvements and future developments building on the study; and a conclusion which summarises the relationship between the research question and the major findings.
	Presentation (10%) To include: academic writing style; depth, scope and accuracy of referencing in the text and final reference list; clarity in organisation, formatting and visual presentation

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CARDIFF METROPOLITAN UNIVERSITY
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CARDIFF SCHOOL OF SPORT

DEGREE OF BACHELOR OF SCIENCE (HONOURS)

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DISCRIMINATIVE POWER OF VALID GAME-RELATED STATISTICS IN THE NATIONAL BASKETBALL ASSOCIATION

(Dissertation submitted under the discipline of Performance Analysis)

Peter Westerman

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DISCRIMINATIVE POWER OF VALID GAME-RELATED STATISTICS IN THE NATIONAL BASKETBALL ASSOCIATION

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TABLE OF CONTENTS

CHAPTER 4: DISCUSSION

CHAPTER 5: CONCLUSION

APPENDICES

LIST OF TABLES

LIST OF FIGURES

DEDICATION

In memory of Bruce Palmer

Pap, my inspiration.

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I would like to thank Dr. Steve Cooper for his continued professional support and expert advice throughout this process.

ABSTRACT

The aim of this study was to investigate the discriminatory power of valid game-related statistics, on the outcome of a basketball game. The sample included 246 games from the Men's National Basketball Association; 2012 - 2013 Regular Season. The games were classified as balanced (equal or below eight points) or unbalanced (above eight points) based on the final score differential. Before analysis, reliability (95% limits of agreement) and validity (kappa) assessment procedures were completed on the raw data. Mann-Whitney *U* (*post-hoc* pairwise) tests with adjusted Bonferroni correction were used to compare 17 game-related statistics between the winning and losing teams, in each category. The statistical significance was set at $P < 0.003$. The analysis highlighted that field goals made, field goal percentage, three points made, three point percentage, defensive rebounds, total rebounds, assists and turn overs significantly differentiate between winning and losing teams, over all games ($P < 0.001$). In addition, unbalanced games had a total of nine performance indicators that were significantly different, with steals also becoming discriminative than in all games. Conversely, for balanced games, field goal percentage and field goals made were the only significant variables that distinguished between winning and losing teams ($P < 0.001$). These findings have numerous practical applications for an NBA team's coach and recruitment scout. Specifically, the coach can utilise the findings to design conditioning programs, regulate training sessions and inform player or tactical selection.

CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

1.1. Introduction

Performance analysis is the investigation of actual sports performance to produce feedback for educational purposes and performance improvement (Hughes & Franks, 2008; O'Donoghue, 2010). The presence of feedback is an important factor in the process of performance enhancement and team development (O'Donoghue, 2010). The traditional method of providing feedback was limited to the volume of subjective information that could accurately be recalled by the coach (Franks & Miller, 1991). Thus, the completion of objective observations through performance analysis enhances the quality, accuracy and amount of feedback produced (Hughes & Franks, 2004). The ability to obtain this valuable information through performance analysis techniques has been used within a variety of sports including basketball, in different ways dependent upon the desired output (Hughes & Franks, 2004).

Performance analysis has become an essential tool for basketball coaches by providing key, in-depth information on individual players, their team and future opponents (Hughes & Bartlett, 2008). This quantitative analysis on such a dynamic game has been increasingly used by sports scientists and coaches, in the hope to highlight significant elements that could separate a win from a loss (Gomez *et al.,* 2008). The uses of game-related statistics to study team and individual performances have also been utilised by basketball coaches and performance analysts in a multitude of ways (Hughes & Franks, 2004).

These key game-related statistics, also known as performance indictors, individually aim to define a specific aspect of a team's performance (Hughes & Bartlett, 2002). Previous research has used performance indicators to highlight differences between successful and unsuccessful teams (Jimenez *et al.,* 2007); differentiate between match starters and non-starters (Gomez *et al.,* 2009) and to identify differences in positional roles for player recruitment process (Sampaio *et al.,* 2006).

1.2. Statistics, reliability and validity

The performance indicators which are generally used in analysis and previous literature are commonly found within the official box-scores of many basketball leagues (Kubatko *et al.,* 2007). These independent variables include; turnovers, blocks, fouls, steals, assists, defensive rebounds, offensive rebounds, free throws attempted, free throws made, field goals attempted, field goals made, three point field goals attempted and three point field goals made. These box statistics are available in the public domain and are collected by official league analysts, using appropriate operational definitions for each performance indicator (FIBA, 2013). This therefore limits personal bias and increases reliability of such data collected (James *et al.,* 2007).

However, the investigation of sports performance must be valid and reliable to support key decisions (O'Donoghue, 2012). The raw data must be proven to be accurate and relevant for such decisions to be based upon (Choi *et al.,* 2007). Therefore, research studies should include an individual assessment of validity and reliability to support any key findings produced (Cooper *et al.,* 2007; O'Donoghue 2007). Whereby, validity refers to an index of error and reflects the ability of a new system to measure a concept, when compared to scores from a criterion measuring system (O'Donoghue, 2010). Similarly, reliability refers to the capacity to obtain consistent and accurate measurements, in a meaningful and repeatable manner (Cooper *et al.,* 2007). Thus, the evaluation of reliability is vital in research, to effectively understand the level of measurement error involved (Atkinson & Nevill, 1998; O'Donoghue, 2007).

1.3. Previous basketball research

The use of game-related statistics in basketball is becoming an increasingly popular tool for performance analysts and researchers (Kubatko *et al.,* 2007). Sampaio and Janeira (2003) considered the discriminatory power of game-related statistics on the outcome of a basketball game, in terms of winning or losing. They found that losing teams in balanced (final score difference [FSD] 8 - 18 points) and unbalanced (FSD > 18 points) games had poor game statistics. Whilst concluding that successful free throws and offensive rebounds were important in close games (FSD < 8 points). Although this study included a large sample size (n = 409 games), it was conducted on teams in the Portuguese Basketball League, considered an inferior league (Sampaio *et al.,* 2006). In addition, there was no effort in this study to assess the validity and reliability of collected data.

Sampaio *et al.,* (2004) investigated the discriminative power of game related statistics, in terms of the level of competition and gender. The sample included 230 games from the International Basketball World Championships within four distinct categories; "men's senior (n = 62), women's senior (n = 62), men's junior (n = 64) and women's junior (n = 62)"

(Sampaio *et al.,* 2004). The study highlighted that the men's teams produced significantly more blocks and fewer steals than the women's teams. In addition, the junior teams produced a lower percentage of assists and more turnovers than senior teams. However, the analysis only focused on 105 games within the sample that were deemed close (FSD < 12 points) and did not take into account the power of these variables on the outcome of a game. Although this information is useful for coaches to regulate training sessions and focus on specific aspects; it does not educate on significant variables that separate a win from a loss. In addition, the study did not asses the validity and reliability of raw data but only stated that the values were collected by International Basketball Federation technicians.

In contrast, Gomez *et al.,* (2008) focused on game-related statistics that discriminate between winning and losing teams when playing at home or away. The sample included 306 games from the Spanish Professional Men's League (ACB); 2004-2005 Regular Season. The analysis highlighted that defensive rebounds (structural coefficient [SC] = 0.42) and assists (SC = 0.38) were significantly different between winning and losing teams in all three categories (all games, home and away). In addition, winning teams' successful field goals (SC = 0.3l) and unsuccessful three point field goals (SC = -0.35) were significantly different from the losing teams, when playing away. The primary focus of the study was on home advantage effect, which as identified, is useful for game preparation. However, it did not take into account the difference between balanced and unbalanced games for an in-depth comparison between game types. Furthermore, resembling previous studies, the data was collected by official league technicians but there was no attempt at assessing the raw data for validity and reliability.

Similarly, Sampaio *et al.,* (2010a) utilised game related statistics from the ACB league but focused on the complete season period of individual players, instead of individual basketball games. This study agreed with Gomez *et al.,* (2008) and added that two point field goals and assists were the most significant for stronger teams; whilst weaker teams performed worse at defensive rebounding ($P < 0.001$). This study did attempt to assess the inter (0.95) and intra-observer (0.97) reliability for all game-related statistics but using correlation analysis on a collective data set. Bland and Altman (1986) highlighted that correlations alone do not confirm the reliability of data produced. In addition, Hughes *et al.,* (2004) supported this and stated that correlations "indicate little sensitivity to the differences” and as such, are deemed an inappropriate process for performance analysis reliability assessment (pp. 201).

Contrary to previous studies, Ibanez *et al.,* (2009) focused on three consecutive games played in a condensed tournament format, as apposed to independent games. The study included 223 games from the Spanish Basketball Federation Under-20 league, over two regular seasons (2005-2007). The analysis identified that turnovers was the only variable that was significantly different between game number; whereby it decreased between the second and third game. Whilst two point field goals made (game one SC = 0.48, game two SC = 0.46 and game three SC = 0.52), defensive rebounds (game one SC = 0.40, game two SC = 0.43 and game three SC = 0.49) and assists (game one SC = 0.38, game two SC = 0.40 and game three SC = 0.39) significantly discriminated between winning and losing teams over all games (SC ≥ 0.30). However, three point field goals made (SC = -0.34) was the only variable to discriminate between winning and losing teams, when game three was considered individually.

Similar to the procedure used by Gomez *et al.,* (2009), this study did not consider balanced and unbalanced games in isolation. In addition, the findings produced are only relevant to the league of which it was focused on (Sampaio *et al.,* 2006). Thus, the results and conclusions therein are limited to inform only the coaches in a Spanish Under-20 league tournament and can not be generalised. Furthermore, the study completed simple inter (0.95) and intra-observer (0.97) reliability tests on five games within the sample, using correlation analysis. However, the study did not treat the variables as individual items and as previously mentioned, correlation alone is an incomplete process of assessing reliability (Bland & Altman, 1986; Hughes *et al.,* 2004). Thus, this study did not provide sufficient evidence for reliability and validity of raw data.

In addition, Csataljay *et al.,* (2009) aimed to identify significant performance indicators that distinguish between winning and losing teams in the 2007 European Basketball Championship (*n* = 54). The study highlighted that for all games, there were 13 performance indicators out of 18 that were significantly different between winning and losing teams. Therefore, for an in-depth analysis, the games were separated into three categories; close games (*n* = 28, FSD ≤ 9), balanced games (*n* = 20, FSD between 10 and 22 points inclusive) and unbalanced games (*n* = 6, FSD > 22 points). Thus, highlighting that winning teams had significantly higher shooting efficiency and less 3 points attempted in close games. Wilcoxon signed ranks tests identified that free throws made ($P < 0.01$), free throw percentage ($P < 0.001$) and defensive rebounds ($P < 0.01$) were also significantly different between winning and losing teams in close games. However, the study highlighted a vast number (13/18) of performance indicators that significantly influenced the outcome of a game, for all games. Thus, the magnitude of these significant variables cause the conclusion obtained to be irrelevant for performance enhancement. In addition, the study included a small sample of 54 games for analysis, with useful information only provided for close games. Furthermore, the study presumed that the data from the official live score sheets were an accurate representation of the games; with no attempt at assessing the reliability and validity.

More recently, Garcia *et al.,* (2013) investigated the discriminatory power of game related statistics on the outcome of a basketball game. The sample included 323 games from the ACB league; split into balanced (FSD ≤ 12 points), unbalanced (FSD between 13 and 28 points) and very unbalanced (FSD > 28 points). The analysis highlighted that in regular season games ($n = 306$), assists, defensive rebounds and field goals made significantly influenced the outcome, in terms of a win or a loss. Whilst in play-off games ($n = 17$), defensive rebounding was the only significant variable ($P < 0.001$, SC ≥ 0.30). These findings coincide with a ten year longitudinal study examining winning and rebounding in America; which stated that 80% of teams that out-rebounded their opponents progressed on to win the game (Krause *et al.,* 2008). In addition, Garcia *et al.,* (2013) suggested that reliability tests were not required for the study, due to the live comparison with the official referees' box scores (kappa above 0.92). However, the process of performance analysis should be supported with the independent analyst's relevant reliability and validity assessment procedures, to interpret and justify the level of measurement error involved in human processing (Cooper *et al.,* 2007; O'Donoghue 2007). Thus, this live process of validation is insufficient in the assessment of data for validity and reliability.

1.4. Rationale

As highlighted, previous research has taken into account various contextual factors such as game location (Gómez *et al.,* 2008), game type (García *et al.,* 2013), players' gender with level of competition (Sampaio *et al.,* 2004) and game final score differences (Sampaio & Janeira, 2003). However, the majority of these studies have focused on European basketball that is conditioned to International Basketball Federation (FIBA) rules

(FIBA, 2013). These rules differ from National Basketball Association (NBA) regulations (NBA Media Ventures LLC, 2013b) and could ultimately impact the significance of the variables associated (Sampaio *et al.,* 2006). These differences include: game time (FIBA = 40mins and NBA = 48mins), player disqualification (FIBA = five fouls and NBA = six fouls), three point distance (FIBA = arc of 6.75m and NBA = arc of 7.24m), time-outs (FIBA = six and NBA = eight) and technical foul consequence (FIBA = two free throws awarded and NBA = one free throw). Furthermore, the NBA court size is slightly larger and the free throw line is over 7cm further back than FIBA regulations. In addition, NBA games utilise three referees, whilst FIBA games are limited to two (FIBA, 2013; NBA Media Ventures LLC, 2013b). Thus, the findings produced are only relevant to the coaches within the leagues of which the research was carried out on; due to differing rules and regulations on game play (Sampaio *et al.,* 2006).

Evidently, there is a need for further investigation on the NBA, due to the limited research and contradicting results produced by previous studies (Sampaio & Janeira, 2003; Sampaio *et al.,* 2004; Csataljay *et al.,* 2009; Ibáñez *et al.,* 2009; Sampaio *et al.,* 2010a; García *et al.,* 2013). Noticeably, there has been no attempt to highlight the key game-related statistics that significantly influence the outcome, in terms of balanced and unbalanced games in the NBA. Furthermore, it is important to highlight that none of these previous studies provide sufficient proof about the validity and reliability of raw data (Choi *et al.,* 2007). These conclusions coincide with the findings by Hughes *et al.,* (2004); which discovered that 70% of performance analysis research papers (presented at world conferences) have not used reliability tests, whilst 15% used inadequate correlation processes. Thus, compatible procedures to assess reliability and validity need to be completed for coaches and scouts to truly rely on and be confident in the findings presented (Hughes *et al.,* 2004; O'Donoghue, 2007).

1.5. Purpose of the present study

The literature suggests that there is a growing demand for performance analysis in basketball to produce important feedback (Kubatko *et al.,* 2007). Furthermore, the potential benefits and effective utilisation of game-related statistics have been used in different studies across varying leagues. The need for effective differentiation of balanced and unbalanced games is required to enhance the ability of in-depth analysis. The limited literature on the National Basketball Association and its growing demand suggests further research is required to provide the relevant knowledge. This knowledge includes potential significant factors, in terms of game-related statistics that impact the outcome of a game. The inconceivable fact that previous research neglected to support their findings with appropriate reliability and validity assessment, promotes a strong case for research into this area. Therefore, the purpose of this study will be to produce a reliable investigation into the discriminatory power of game-related statistics, in terms of winning and losing in the NBA. With the aim to increase knowledge and inform coaching practice, whilst confidently providing information that could be utilised by scouts for recruitment purposes within the NBA.

CHAPTER II

METHODS

2.0. Methods

2.1. Sample

The sample included 246 games from the Men's National Basketball Association (NBA), 2012-2013 Regular Season. The desired game-related statistics were gathered from the official box scores available from the NBA website (NBA Media Ventures LLC, 2013a). These included; turnovers, steals, fouls, blocks, assists, defensive rebounds, offensive rebounds, free throws made, free throws attempted, field goals attempted, field goals made, three point field goals attempted, three point field goals made and points scored, by both playing teams (see Appendix A for definitions). In addition, the study was approved by the Cardiff Metropolitan University ethics committee (Appendix M).

This data was then collected and collated in Microsoft Excel (version 11.8404.8405) computer software (Microsoft, 2003); with field goal percentage, three point field goal percentage, free throw percentage, total rebounds and the final score difference calculated for each game. The games were then separated into two categories, balanced and unbalanced. Based on previous research, this differentiation was dependent on the final score differential (FSD) of each game (Sampaio & Janeira, 2003; Gomez *et al.,* 2008). Therefore, identification of games into the correct classification was dependent on the FSD median of all games. Thus, balanced games had a score differential of less than and equal to eight points and unbalanced games greater than eight points. This provided the required categories of equal proportion for controlled analysis; balanced games (n = 124) and unbalanced games (n = 122). However, before analysis, validity and reliability assessment procedures were completed on the raw data.

2.2. Validity of sourced data

The criterion-related validity was assessed using Cohen's kappa to quantify the agreement between the official NBA scores and results from the independent analysis (Cohen, 1960).

2.2.1. Procedure for notational data collection

This independent real-time notational analysis was completed on two randomly selected games within the sample (0.81%); from footage available through NBA Game Time, League Pass (NBA Media Ventures LLC, 2013a). The games included; Miami against Boston, played 30th October 2012 and New York against Dallas, played 9th November

2012. The data collection focused on thirteen key variables from the official box statistics. Therefore, operational definitions were established for all these performance indicators (Appendix A); based on coaching literature and the official NBA rulebook (Oliver, 2004; McGee, 2007; Ramen, 2007; NBA Media Ventures LLC, 2013b).

Before testing, a pilot study was completed to check for any interventions that needed to be made to the procedures or definitions. This provided the opportunity to check that the system was feasible and amend variables if necessary (O'Donoghue, 2010). Thus, the pilot study was concluded on the game between San Antonio and Indiana, played on 5th November 2012. After completion of the pilot, it was evident that each variable box for notation needed to be spatially enhanced; which limited the time spent notating the specific action and left more time for observation. Furthermore, the analysis utilised hand-notation techniques to record data; as opposed to computer assisted software such as Dartfish 7.0 (Dartfish, 2013) or Nacsport version 1.3.400 (Nacsport, 2013), where accidental coding is more likely to occur on computer-based entry (Hughes & Franks, 2004; Cooper *et al.,* 2007; O'Donoghue, 2010).

2.2.2. Data analysis for validity

The official NBA results (criterion system) and the independent notation analysis system individually produced thirteen statistical elements on each playing team, over the two selected games. The data was then collected in Microsoft Excel (Microsoft, 2003) for data handling and transferred into SSPS software version 20.0 for statistical analysis (IBM Corp, 2011). The games were kept separated for in-depth analysis and production of multiple validity results, as well as one combined measure. The kappa statistic was used to quantify the agreement between the criterion scores and the independent analysis scores (Cohen, 1960).

Choi *et al.,* (2007) highlighted that kappa is the only statistic with construct validity for real-time basketball performance analysis and further suggested higher agreement thresholds than that originally proposed by Altman (1991). The values of kappa were obtained from each individual game and both games combined. These values were then compared to *Choi et al.'s* (2007) recommended threshold values, to indicate strength of agreement between scores (Table 1).

Table 1: Illustrates the strength of agreement in kappa threshold values

Kappa value	Strength of agreement
$0.00 < \kappa \leq 0.59$	Unacceptable
$0.60 \leq \kappa \leq 0.79$	Acceptable
$0.80 \leq \kappa < 1.00$	Good

2.3. Reliability of sourced data

The intra-observer reliability was obtained to assess the data entered into the analysis system, across all thirteen variables independently. The estimation of reliability was completed using Bland and Altman (1999) non-parametric techniques suggested by Cooper *et al.,* (2007). This method for assessing the reliability of data will be clearly outlined.

2.3.1. Procedure for notational data collection

The test-retest analysis was performed from footage available through NBA Game Time, League Pass (NBA Media Ventures LLC, 2013a); on the game between San Antonio and Oklahoma City, played 1st November 2012. The data collection included all thirteen variables; field goals made, field goals attempted, three points made, three points attempted, free throws made, free throws attempted, offensive rebounds, defensive rebounds, assists, steals, blocks, turn overs and personal fouls. In addition, the analyst notated (under the same conditions) the sum of both teams for each variable as opposed to independent teams.

The game was split into one minute time cells (n = 48), to produce a sufficient sample size for assessing agreement (Altman, 1991). The analyst, therefore, had to hand-notate the frequency of each performance indicator within a minute time frame; whilst the count was reset when the analyst entered a new time cell. This produced 48 sets of frequency counts for each variable that were compared to the re-test scores within the same time frame. The analyst was required to leave a seven day time period between the test and retest; which accounted for the process of familiarisation with the notation and the ability to retain and recall information from the first test.

Before the actual data collection, it was important to pilot the procedure to test for any modifications that needed to be made. Thus, a pilot study took place on the game between San Antonio and Indiana, played on 5th November 2012. This identified that the process was difficult to time keep each cell and record all thirteen variables for both teams simultaneously in real time. Therefore, the analyst implemented pause and rewind features to provide sufficient time to record observed results. Furthermore, the utilisation of four separate sheets for each twelve minute quarter allowed spatial enhancement of variable boxes and promotion of time spent observing game footage.

2.3.2. Data analysis of test-retest

This data was then analysed using Bland and Altman's (1999) non-parametric '95% Limits of Agreements' (LoA), to indicate agreement between test and retest over the thirteen reliability indices (Cooper *et al.,* 2007). Each performance indicator was treated as a separate item, with the production of a Bland and Altman plot for each. These X-Y scatter diagrams are constructed for each variable by; plotting the differences between the test and retest frequencies on the Y-axis (test – retest) and the means of the test retest scores on the X-axis (Bland and Altman, 1986). The 95% LoA is recommended by The British Association of Sport and Exercise Sciences (BASES, 2013); with a 95% confidence advised by both the British Standards Institution and the International Organization for Standardization (BSI, 1987; ISO, 2013). Therefore, the 97.5th and 2.5th percentiles were superimposed on each variable plot, which provided numerical and visual comparisons between variables.

The random variation and systematic bias were quantified between the test and re-test scores. The median sign test takes into account values with a difference of zero, which promotes the usefulness of this test (O'Donoghue, 2012). Thus, a median sign test for each variable was performed to assess the systematic bias for statistical significance. The random variation was highlighted for each variable, with the visual aid of the Bland and Altman Plot.

Furthermore, the observed proportion of time cells that had perfect test-retest agreement was calculated for each variable; where test minus re-test equates to zero. This observed proportion of agreement was calculated by dividing the number of perfect agreement cells by the total time cells. In addition, Cooper *et al.,* (2007) states that sports performance analysts should "report the proportion of frequency scores with differences within a certain reference value" (pp. 98). Therefore, the observed proportion of agreement was also calculated within a reference value ±1 which was suggested as no practically important difference (Nevill *et al.,* 2001). Hamilton and Stamey (2007) stated that confidence intervals should always be provided to assess the variability. Consequently, each observed proportion of agreement was, therefore, supported with a confidence interval across all thirteen variables.

2.4. Data analysis

The data analysis process used SPSS software version 20.0 to utilise the desired functions available (IBM Corp, 2011). The sample satisfied non-parametric assumptions for analysis. Descriptive statistics of median and Inter-quartile range across all game-related variables for winning and losing teams were calculated. These statistics were calculated for balanced, unbalanced and all games. Mann-Whitney *U* tests were then performed for each variable across the winning and losing teams (Mann & Whitney, 1947; O'Donoghue, 2012). This identified significant statistical differences between the winning and losing teams and gave the ability for comparison between balanced and unbalanced games. In addition, Altman (1991) suggests that the statistical significance should be set at $P < 0.05$. However, due to the number of paired tests, the significance was adjusted with a Bonferroni correction (0.05 / number of comparisons) to account for type 1 (probability = α) error (Nevill *et al.,* 2007; O'Donoghue, 2010). This increased the statistical power of the test and enhanced the probability to correctly indentify an actual effect, as opposed to false positives; thus controlling the familywise error rate (Lehmann & Romano, 2005; Howell, 2012). This, consequently, maximised the degree of confidence and further increased the accuracy and truthfulness of results (Nevill *et al.,* 2007).

CHAPTER III

RESULTS

3.0. Results

3.1. Validity

Table 2 shows the official National Basketball Association (NBA) scores and the independent analyst's scores for both games, over the thirteen performance indicators. These results were utilised to calculate the required values of kappa for each game and both combined (Table 3).

Table 2: Game related statistics from the criterion system and the independent observer's notational analysis (Miami vs Boston and New York vs Dallas)

	Game 1				Game 2			
	Miami		Boston		New York		Dallas	
	C.S	I.O.S	C.S	I.O.S	C.S	I.O.S	C.S	I.O.S
Field Goals Attempted	79	77	75	75	84	84	81	81
Field Goals Made	43	46	39	39	35	34	33	33
3-Point Attempted	16	14	13	13	22	22	28	28
3-Point Made	8	8	6	6	8	8	8	8
Free Throws Attempted	32	32	28	28	38	38	23	23
Free Throws Made	26	26	23	23	26	26	20	20
Offensive Rebounds	5	6	7	7	11	11	9	8
Defensive Rebounds	31	31	34	33	32	33	41	41
Assists	25	25	24	26	17	15	17	19
Steals	8	9	4	4	12	11	4	2
Blocks	5	5	2	2	4	4	3	3
Turn Overs	8	7	15	15	9	10	20	22
Personal Fouls	20	20	23	23	21	21	28	28

Key: C.S. = Criterion Scores; I.O.S = Independent observer scores

As shown in Table 3, the highest value of kappa was obtained from the game between Miami and Boston (0.68). In addition, the second game between New York and Dallas (0.639) produced a similar value of kappa. Whilst the combined kappa value for both games resulted in a score of 0.662.

Table 3: Kappa values for both analysed games and combined

Games	Kappa value
Miami – Boston	0.68
New York – Dallas	0.639
Combined	0.662

Figure 1, highlights the three produced kappa values and a comparison with Choi *et al.'s* (2007) recommended thresholds for strength of agreement. As shown, the first game between Miami and Boston (0.68) indicates an acceptable strength of agreement. The second game between New York and Dallas (0.639) further suggests an acceptable strength of agreement. Whilst the overall combined kappa value (0.662) also concludes an acceptable strength of agreement.

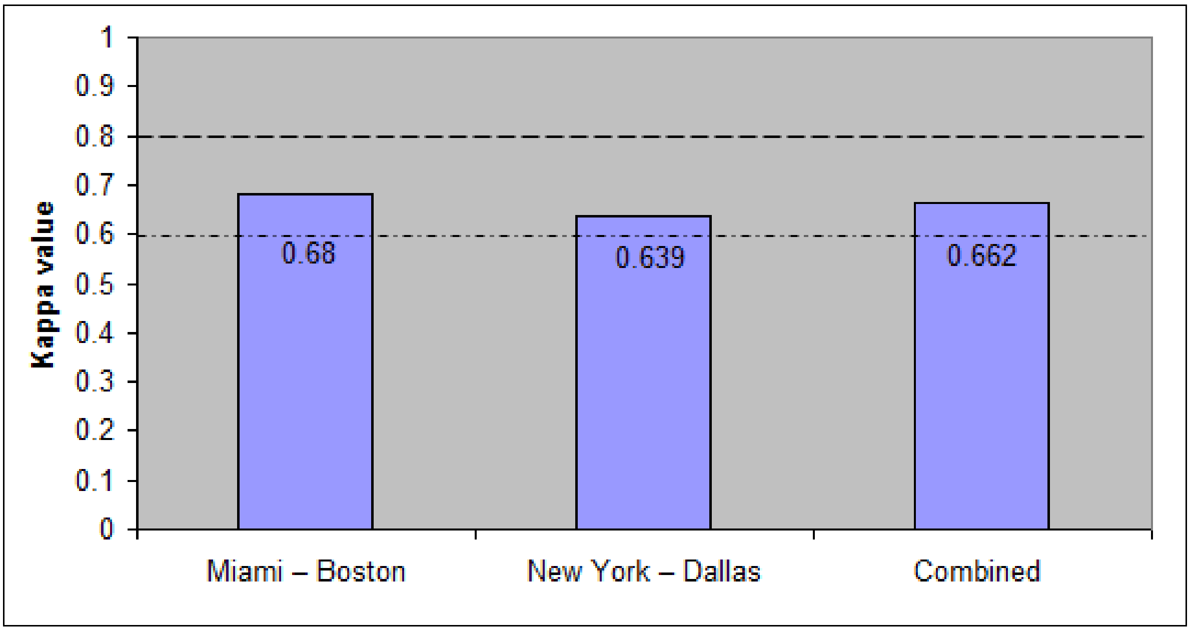

Figure 1: Illustrates Choi *et al.'s* (2007) kappa score thresholds and comparison with results to indicate strength of agreement. Key: Greater than (__________) indicates a good strength of agreement and (-.-.-.-.-.-.-.-.-.-.-) indicates an acceptable strength.

3.2. Reliability

Table 4 shows the test and re-test scores for each performance indicator, along with a time cell frequency count. It could be argued that three points attempted (34), three points made (11), and blocks (10) have perfect agreement of total values. However, further observation of Table 4 highlights that for three points attempted the analyst only recorded the same data in 45 of the 48 minute time cells.

Table 4: Key reliability data on test and retest totals and proportion of agreed time cells for each performance indicator.

Performance Indicator	Test total	Retest total	Same data in test and re-test between independent cells.
Field Goals Attempted	173	175	40/48
Field Goals Made	63	64	45/48
3-Point Attempted	34	34	45/48
3-Point Made	11	11	48/48
Free Throws Attempted	39	40	47/48
Free Throws Made	29	30	47/48
Offensive Rebounds	12	13	45/48
Defensive Rebounds	62	68	42/48
Assists	48	50	39/48
Steals	7	10	45/48
Blocks	10	10	48/48
Turn Overs	21	28	41/48
Personal Fouls	21	28	46/48

Therefore, the assessment of reliability will be presented for each independent performance indicator in the following manner. A Bland and Altman plot with percentiles for visual analysis will be produced, alongside a frequency and percentage table. Whilst the random variation, systematic bias and 95% limits of agreement will be highlighted for each. In addition, field goals attempted and field goals made will be used as examples with a plot (Figures 2 and 3) and frequency-percentage table (Tables 5 and 6) included in the results. Whilst the unique plots and tables for the following eleven independent variables can be found in Appendix B to Appendix L and will be highlighted throughout.

3.2.01. Field goals attempted

Figure 2 illustrates a Bland and Altman plot with superimposed 97.5th and 2.5th percentiles. Observation of this plot indicates little evidence of random variation and systematic bias. Additionally, the median sign test (Table 7) suggested that the analyst only recorded minimal higher scores on the re-test than the test (median = 0; values equal to the median = 40, above the median = 3 and below the median = 5). Consequently, the statistical systematic bias was not significant (*P* = 0.727).

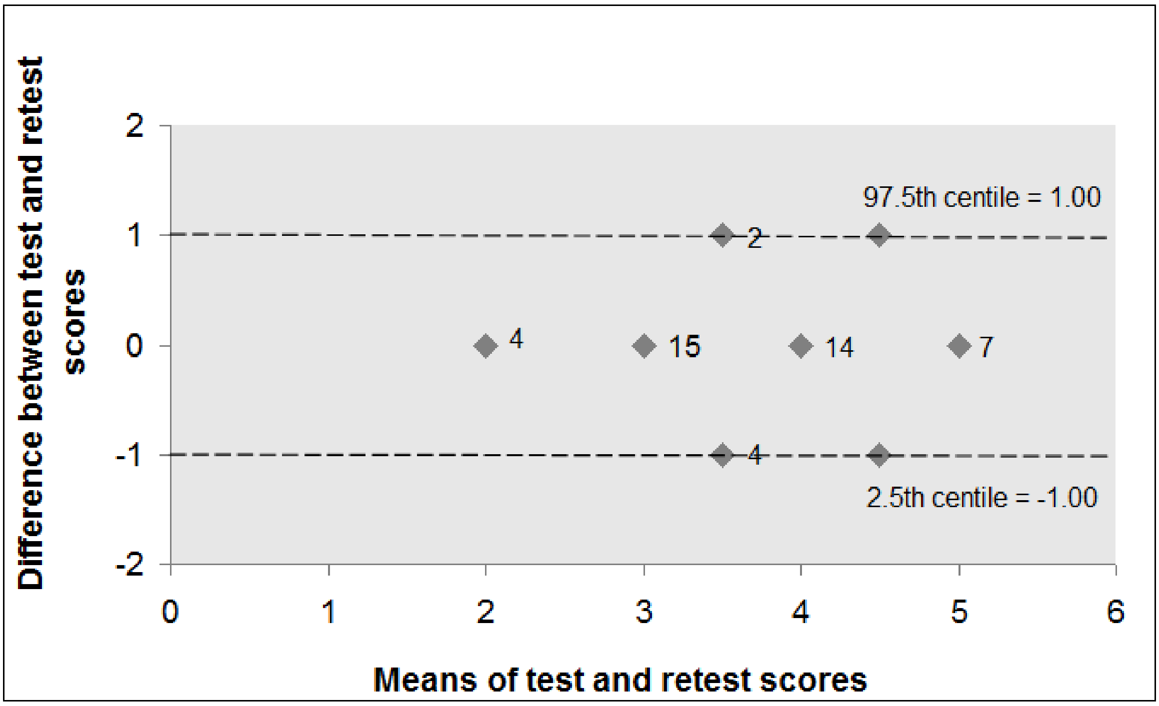

Figure 2: Bland and Altman plot representing the test and retest results for field goals attempted. The non-parametric 95% limits of agreement (_ _ _ _ _ _ _ _ _ _) are superimposed on the plot. Points identified as '◆x' portray the number of data points on that co-ordinate.

Table 5 shows that 40 cells out of the 48 were in perfect agreement between test and retest for field goals attempted (83.3%), with a confidence interval (CI) 72.7% to 93.9% (Table 7). In addition, when the reference value of ±1 is applied 48 out of 48 time cells are in agreement (100%, CI: 100%). The 95% of the differences between the test and re-test scores were between: 2.5th centile = -1.00 and 97.5th centile = 1.00. Thus, the limits of agreement are narrow enough to be confident in the accuracy of results.

Table 5: Field goals attempted cell frequency and percentage distribution

Difference	Frequency	Percentage
-1	5	10.4
0	40	83.3
1	3	6.3
Total	48	100

3.2.02. Field goals made

Figure 3 illustrates a Bland and Altman plot with superimposed 97.5th and 2.5th percentiles. Observation of this plot indicates little evidence of random variation and systematic bias. Additionally, the median sign test (Table 7) suggested that the analyst recorded very similar scores on the re-test (median = 0; values equal to the median = 45, above the median = 1 and below the median = 2). Consequently, the statistical systematic bias was not significant (*P* = 1.00).

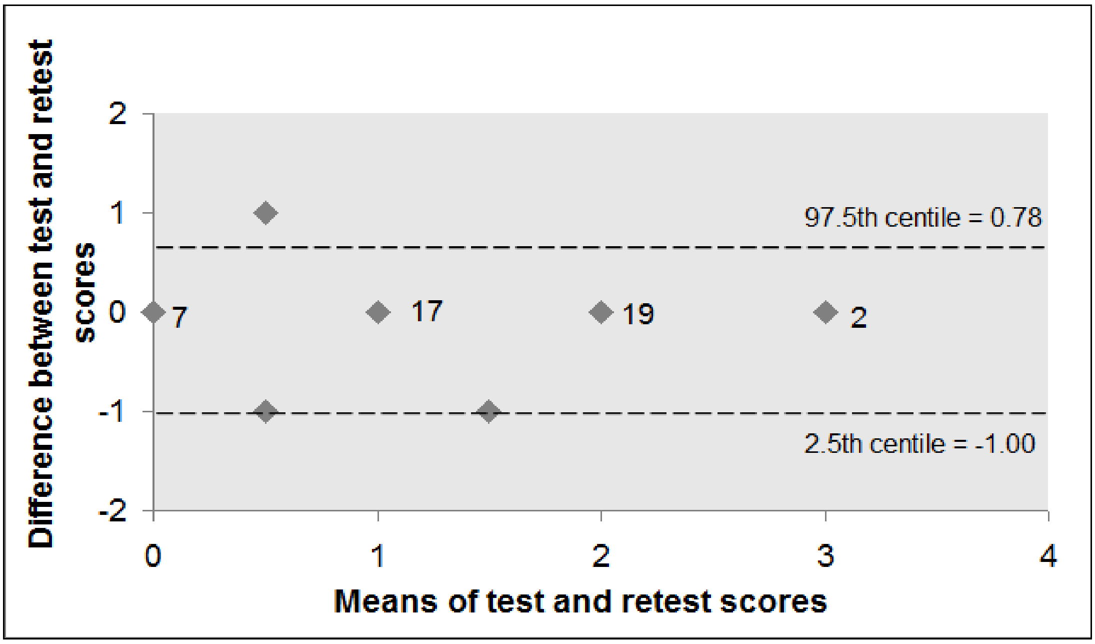

Figure 3: Bland and Altman plot representing the test and retest results for field goals made. The non-parametric 95% limits of agreement (– – – – – – – – – –) are superimposed on the plot. Points identified as ' ◆x' portray the number of data points on that co-ordinate.

Tables 6 and 7 show that 45 cells out of the 48 were in perfect agreement between test and retest for field goals made (93.8%, CI: 87 to 100%). In addition, when the reference value of ±1 is applied 48 out of 48 time cells are in agreement (100%, CI: 100%). Furthermore, 95% of the differences between the test and re-test scores were between:

2.5th centile = -1.00 and 97.5th centile = 0.78 (Figure 3). Thus, the limits of agreement are narrower than field goals attempted and enough to be confident in the accuracy of results.

Table 6: Field goals made cell frequency and percentage distribution

Difference	Frequency	Percentage
-1	2	4.2
0	45	93.8
1	1	2.1
Total	48	100

The results for field goals attempted and field goals made that were discussed previously have been added to Table 7, along with the remaining 11 variables. Table 7 summarises the results of the median sign test and provides percentile values, percentage of total agreement (PA = 0), percentage of agreement within a reference value (PA ±1) and retrospective confidence intervals for all individual performance indicators.

Table 7: Concluding data on test-retest scores for all thirteen performance indicators.

Performance Indicators	Median (*P* sign test)	Percentiles		PA = 0 (%)	Confidence Interval (%)	PA ±1 (%)	Confidence Interval (%)
		2.5%	97.5%				
Field Goals Attempted	0.00 (0.727)	-1.00	1.00	83.3	72.7 to 93.9	100	100
Field Goals Made	0.00 (1.000)	-1.00	0.78	93.8	87.0 to 100	100	100
3-Point Attempted	0.00 (1.000)	-1.00	1.55	93.8	87.0 to 100	97.92	93.9 to 100
3-Point Made	0.00 (1.000)	0.00	0.00	100	100	100	100
Free Throws Attempted	0.00 (1.000)	-0.78	0.00	97.9	93.8 to 100	100	100
Free Throws Made	0.00 (1.000)	-0.78	0.00	97.9	93.8 to 100	100	100
Offensive Rebounds	0.00 (1.000)	-1.00	0.78	93.8	87.0 to 100	100	100
Defensive Rebounds	0.00 (0.031)*	-1.00	0.00	87.5	78.1 to 96.9	100	100
Assists	0.00 (1.000)	-2.00	1.78	81.3	70.3 to 92.3	93.75	86.9 to 100
Steals	0.00 (0.250)	-1.00	0.00	93.8	87.0 to 100	100	100
Blocks	0.00 (1.000)	0.00	0.00	100	100	100	100
Turn Overs	0.00 (0.016)*	-1.00	0.00	85.4	75.4 to 95.4	100	100
Personal Fouls	0.00 (1.000)	-0.78	0.78	95.8	90.1 to 100	100	100

***** Statistically significant systematic bias (p <0.05)

3.2.03. Three points attempted

Appendix B illustrates a Bland and Altman plot with superimposed 97.5th and 2.5th percentiles. Observation of this plot indicates some evidence of random variation and systematic bias. Additionally, the median sign test (Table 7) suggested that the analyst only recorded minimal higher scores on the re-test than the test (median = 0; values equal to the median = 45, above the median = 1 and below the median = 2). Consequently, the statistical systematic bias was not significant (*P* = 1.000). Appendix B and Table 7 also show that 45 cells out of the 48 were in perfect agreement between test and retest for three points attempted (93.8%, CI: 87.0 to 100%). In addition, when the reference value of ±1 is applied 47 out of 48 time cells are in agreement (97.92%, CI: 93.9 to 100%). Moreover, 95% of the differences between the test and re-test scores were: 2.5th centile = -1.00 and 97.5th centile = 1.55.

3.2.04. Three points made

Appendix C illustrates a Bland and Altman plot with superimposed 97.5th and 2.5th percentiles and a cell frequency-percentage table. Observation of this plot indicates no evidence of random variation and systematic bias. Additionally, the median sign test (Table 7) suggested that the analyst recorded the same scores on both tests (median = 0; values equal to the median = 48, above the median = 0 and below the median = 0). Consequently, the statistical systematic bias was not significant (*P* = 1.000). Appendix C also shows that 48 cells out of the 48 were in perfect agreement between test and retest for three points made (100%), with a CI: 100% (Table 7). Therefore, for this variable, reporting the results within a reference value was not necessary due to the already perfect agreement. In addition, 95% of the differences between the test and re-test scores were: 2.5th centile = 0.00 and 97.5th centile = 0.00.

3.2.05. Free throws attempted

Observation of Appendix D indicates little evidence of random variation and systematic bias. Additionally, the median sign test (Table 7) suggested that the analyst only recorded very minimal higher scores on the re-test than the test (median = 0; values equal to the median = 47, above the median = 0 and below the median = 1). Evidently, the statistical systematic bias was not significant (*P* = 1.000). Appendix D and Table 7 also show that 47 cells out of the 48 were in perfect agreement (PA = 0) between test and retest (97.9%, CI: 93.8 to 100%). In addition, when the reference value of ±1 is applied (PA±1) 48 out of 48 time cells are in agreement (100%, CI: 100%). Furthermore, 95% of the differences between the test and re-test scores were between: 2.5th centile = -0.78 and 97.5th centile = 0.00.

3.2.06. Free throws made

Appendix E reports similar findings to free throws attempted, suggesting little evidence of random variation and systematic bias. The median sign test also identified the same findings as free throws attempted, whereby: (median = 0; values equal to the median = 47, above the median = 0 and below the median = 1) and the statistical systematic bias was not significant (P = 1.000). Furthermore, the results identified that PA = 0 (97.9%, CI: 93.8 to 100%) and PA±1 (100%, CI: 100%) are good (Table 7). In addition, 95% of the differences between the test and re-test scores were between: 2.5th centile = -0.78 and 97.5th centile = 0.00.

3.2.07. Offensive rebounds

Appendix F includes a Bland and Altman plot with 95% limits of agreement represented and a percentage distribution table. The plot highlights that there is minimal random variation and systematic bias. Furthermore, the calculation of the median sign test identified that if any, the retest produced slightly higher scores than the test (median = 0; values equal to the median = 45, above the median = 1 and below the median = 2) but was not statistically significant (P = 1.000). Table 7 obtains the results for offensive rebounds and identifies that PA = 0 (93.8%, CI: 87.0 to 100%) and PA±1 (100%, CI: 100%). The 95% of the differences between the test and re-test scores were between: 2.5th centile = -1.00 and 97.5th centile = 0.78.

3.2.08. *Defensive rebounds*

Appendix G illustrates a Bland and Altman plot with superimposed 97.5th and 2.5th percentiles. Table 7 shows that the agreement between test and retest is good with the PA = 0 (87.5%, CI: 78.1 to 96.9%) and PA±1 (100%, CI: 100%). However, observation of this plot indicates evidence of random variation and highlights potential systematic bias. Additionally, the median sign test (Table 7) suggested that the analyst recorded significantly higher scores on the re-test than the test (median = 0; values equal to the median = 42, above the median = 0 and below the median = 6). Consequently, the statistical systematic bias was significant (P = 0.031). In addition, 95% of the differences between the test and re-test scores were between: 2.5th centile = -1.00 and 97.5th centile = 0.00.

3.2.09. *Assists*

Appendix H includes a Bland and Altman plot with 95% limits of agreement represented and percentage distribution table. The plot highlights that there is little random variation and systematic bias. Furthermore, the calculation of the median sign test identified that if any, the retest produced slightly higher scores than the test (median = 0; values equal to the median = 39, above the median = 4 and below the median = 5) but was not statistically significant (P = 1.000). Table 7 also obtains the results for assists and identifies that PA = 0 (81.3%, CI: 70.3 to 92.3%) and PA±1 (93.75%, CI: 86.9 to 100%). The 95% of the differences between the test and re-test scores were between: 2.5th centile = -2.00 and 97.5th centile = 1.78.

3.2.10. *Steals*

Appendix I illustrates a Bland and Altman plot with superimposed 97.5th and 2.5th percentiles. Table 7 shows that the agreement between test and retest is good with the PA = 0 (93.8%, CI: 87.0 to 100%) and PA±1 (100%, CI: 100%). Further observation of this plot also indicates some evidence of random variation and highlights potential systematic bias. Additionally, the median sign test (Table 7) suggested that the analyst recorded significantly higher scores on the re-test than the test (median = 0; values equal to the median = 45, above the median = 0 and below the median = 3). However, the statistical systematic bias was not significant (P = 0.250). In addition, 95% of the differences between the test and re-test scores were between: 2.5th centile = -1.00 and 97.5th centile = 0.00.

3.2.11. Blocks

Appendix J highlights that there is no random variation and systematic bias. Furthermore, the calculation of the median sign test identified that the test produced the same values as the retest (median = 0; values equal to the median = 48, above the median = 0 and below the median = 0) and was not statistical significant (P = 1.000). Table 7 highlights that the test and retest scores are in perfect agreement when PA = 0 (100%, CI: 100%). The 95% of the differences between the test and re-test scores were: 2.5th centile = 0.00 and 97.5th centile = 0.00.

3.2.12. Turn overs

Appendix K illustrates a Bland and Altman plot with superimposed 97.5th and 2.5th percentiles. Table 7 shows that the agreement between test and retest is good with the PA = 0 (85.4%, CI: 75.4 to 95.4%) and PA±1 (100%, CI: 100%). However, observation of this plot indicates evidence of random variation and highlights potential systematic bias. Additionally, the median sign test (Table 7) suggested that the analyst recorded significantly higher scores on the re-test than the test (median = 0; values equal to the median = 41, above the median = 0 and below the median = 7). Consequently, the statistical systematic bias was significant (P = 0.016). In addition, 95% of the differences between the test and re-test scores were: 2.5th centile = -1.00 and 97.5th centile = 0.00.

3.2.13. Personal fouls

Appendix L includes a Bland and Altman plot with 95% limits of agreement represented and percentage distribution table. The plot highlights that there is little random variation and no systematic bias. Furthermore, the calculation of the median sign test identified that there were two instances of equal difference between the test and retest (median = 0; values equal to the median = 46, above the median = 1 and below the median = 1) and was not statistically significant (P = 1.000). Table 7 also obtains the results for personal fouls and identifies that PA = 0 (95.8%, CI: 90.1 to 92.3%) and PA±1 (100%, CI: 100%). The 95% of the differences between the test and re-test scores were: 2.5th centile = -0.78 and 97.5th centile = 0.78.

3.2.14. Reliability conclusion

The previous results highlighted that the agreement between the test and retest scores for the majority of performance indicators was acceptable (Table 7). The recorded results for PA = 0 ranged from 81.3% (CI: 70.3% to 92.3%) for assists, to 97.9% (CI: 93.8% to 100%) for free throws attempted and free throws made. Whilst, three points made and blocks showed perfect agreement in all 48 time cells (100%, CI: 100%). In addition, three points attempted (97.92%, CI: 93.9% to 100%) and assists (93.75%, CI: 86.9% to 100%) were the only two performance indicators that did not produce 100% when considered in terms of the reference value ±1. For each variable, the respective limit of agreement is small enough to be confident in the accuracy of scores between the test and retest. However, defensive rebounds (P = 0.031) and turn overs (P = 0.016) were the only variables to show statistical systematic bias ($P < 0.05$) and respective results should be tempered to the fact of this poor reliability.

3.3. Data analysis

3.3.1. All games

Table 8 shows the median values and inter-quartile ranges (IQR) across all 17 game-related statistics of winning and losing teams, over all 246 games. The Mann-Whitney *U* (*post-hoc* pairwise) test with adjusted Bonferroni correction highlighted that field goals made ($P < 0.001$), field goal percentage ($P < 0.001$), three points made ($P < 0.001$), three point percentage ($P < 0.001$), defensive rebounds ($P < 0.001$), total rebounds ($P < 0.001$), assists ($P < 0.001$) and turn overs ($P < 0.001$) significantly differentiate between winning and losing teams, over all games (Table 8).

Table 8: Descriptive statistics of median (IQR) across all games and variables between the winning and losing teams.

	Winning Teams	Losing Teams
Field Goals Attempted	82 (9)	82 (9.3)
Field Goal Made	38.5 (5)*	34 (6)
Field Goal Percentage	47.3 (7)*	42.3 (7.5)
3-Point Attempted	19 (9)	20 (7)
3-Point Made	7 (4.25)*	6 (3.2)
3-Point Percentage	38.9 (14.3)*	33.3 (14.1)
Free Throw Attempted	23 (9)	22 (8)
Free Throws Made	17 (8)	16 (7)
Free Throw Percentage	76.9 (14.3)	75 (13.1)
Offensive Rebounds	10.5 (6)	11 (6)
Defensive Rebounds	32 (6)*	29 (6)
Total Rebounds	43 (8.3)*	40 (8)
Assists	23 (6)*	20 (6)
Steals	8 (4)	7 (4)
Blocks	5 (4)	5 (3)
Turn Overs	14 (5)*	15 (6)
Personal Fouls	20 (5.3)	21 (6)

* Significant to losing teams ($P < 0.003$)

Figures 4 and 5 illustrate the median differences for each variable between the winning and losing teams. These median differences are in relation to the winning teams; whereby the positive variables are associated with the winning teams, whilst the negative variables are accomplished more by the losing teams. Figure 4 shows that the median of each independent variable is higher in winning teams than losing, with the exception of; offensive rebounds (-0.5), three point attempted (-1), turn overs (-1) and fouls (-1). Whilst, the median field goals attempted and median blocks are the same for both winning and losing teams.

Evidently, this suggests that turn overs is the only significant variable that produces a greater median for losing teams; whilst field goals made (+4.5), field goal percentage (+5), three points made (+1), three point percentage (+5.6), defensive rebounds (+3), total rebounds (+3) and assists (+3) are all significant variables, with higher median values for winning teams (Figure 4).

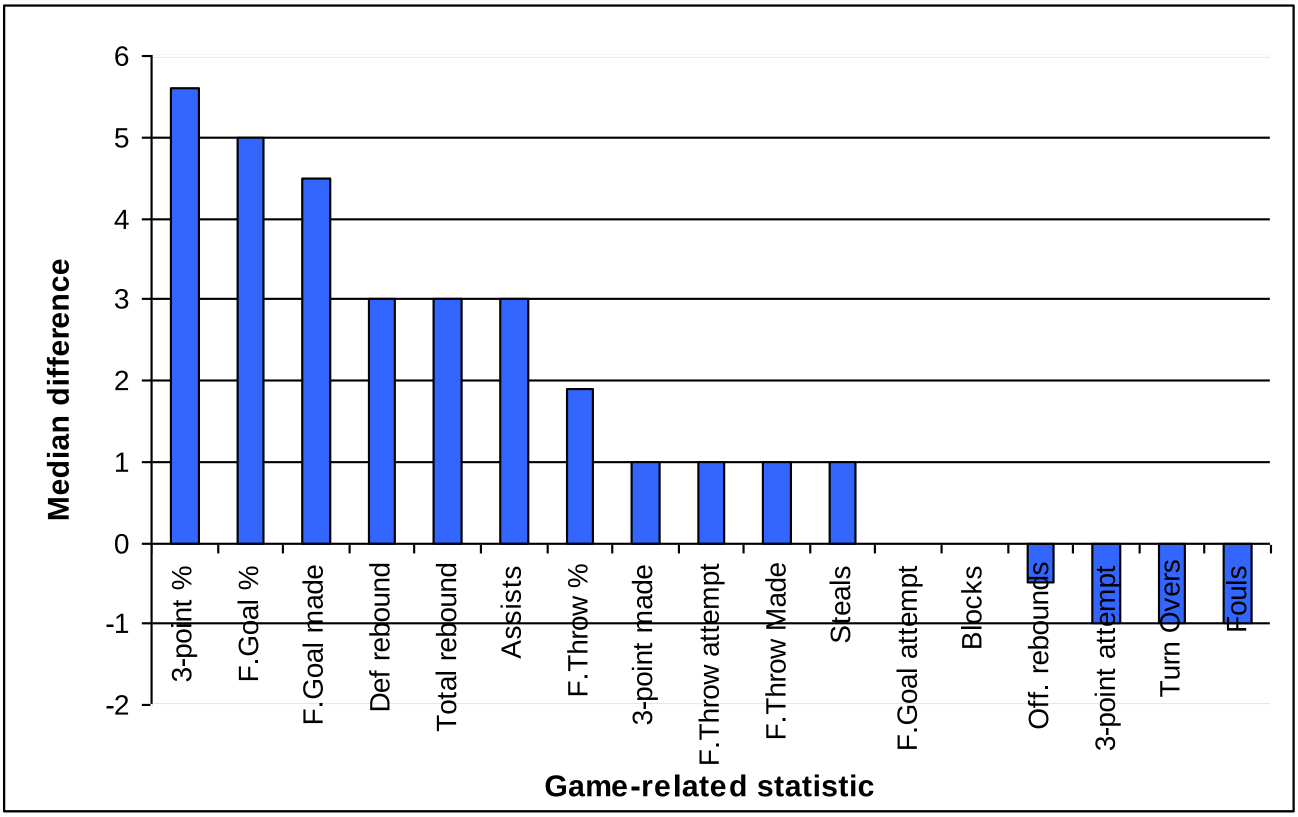

Figure 4: The median differences for each variable between winning and losing teams over all games.

3.3.2. Balanced and unbalanced games

Table 9 shows the median and IQR values across all variables, for both balanced (final score differential ≤ 8) and unbalanced (final score differential > 8) games separately. The Mann-Whitney *U* test indentified that field goals made (*P* < 0.001) and field goal percentage (*P* < 0.001) are the only significant variables, which distinguish between winning and losing teams for balanced games (Table 9).

Table 9: Descriptive statistics of median (IQR) across all variables between balanced and unbalanced games.

	Balanced (*n* = 124)		Unbalanced (*n* = 122)	
	Winning Teams	Losing Teams	Winning Teams	Losing Teams
Field Goals Attempted	82 (7)	83 (10)	81 (10)	80 (11)
Field Goal Made	38 (5)*	36 (6)	39 (6)*	33 (6)
Field Goal Percentage	46.2 (5.4)*	43 (6.8)	49.1 (8.5)*	41.2 (7.9)
3-Point Attempted	19 (8)	20 (7.8)	20 (8)	18.5 (7)
3-Point Made	7 (4.7)	7 (4)	7.5 (4.2)*	6 (4)
3-Point Percentage	36.8 (16)	33.3 (13.4)	41.1 (13.2)*	32.5 (15.2)
Free Throw Attempted	23 (10)	22 (9)	22 (10)	21 (8)
Free Throws Made	17.5 (9)	17 (8)	17 (7.2)	16 (8)
Free Throw Percentage	75.9 (15)	76.8 (12.4)	77.6 (13.7)	74.3 (13.5)
Offensive Rebounds	11 (5.8)	11 (6)	10 (5)	11 (6.2)
Defensive Rebounds	31 (6)	30 (5)	32 (6)*	28 (5)
Total Rebounds	43 (8)	41 (8.7)	43 (9)*	39 (8)
Assists	22 (6.7)	21 (6)	24 (6)*	19 (6)
Steals	8 (3)	7 (4)	9 (4)*	7 (4)
Blocks	5 (4)	5 (2.8)	5 (4.2)	4 (3)
Turn Overs	14 (6)	14 (5)	14 (5)*	16 (5)
Personal Fouls	20 (6.8)	21 (6)	20 (5)	20 (5)

* Significant to losing teams (*P* < 0.003)

Conversely, unbalanced games had a total of nine performance indicators that were significantly different between winning and losing teams (Table 9). These included: field goals made ($P < 0.001$), field goal percentage ($P < 0.001$), three points made ($P < 0.001$), three point percentage ($P < 0.001$), defensive rebounds ($P < 0.001$), total rebounds ($P < 0.001$), assists ($P < 0.001$), steals ($P < 0.001$) and turn overs ($P < 0.001$).

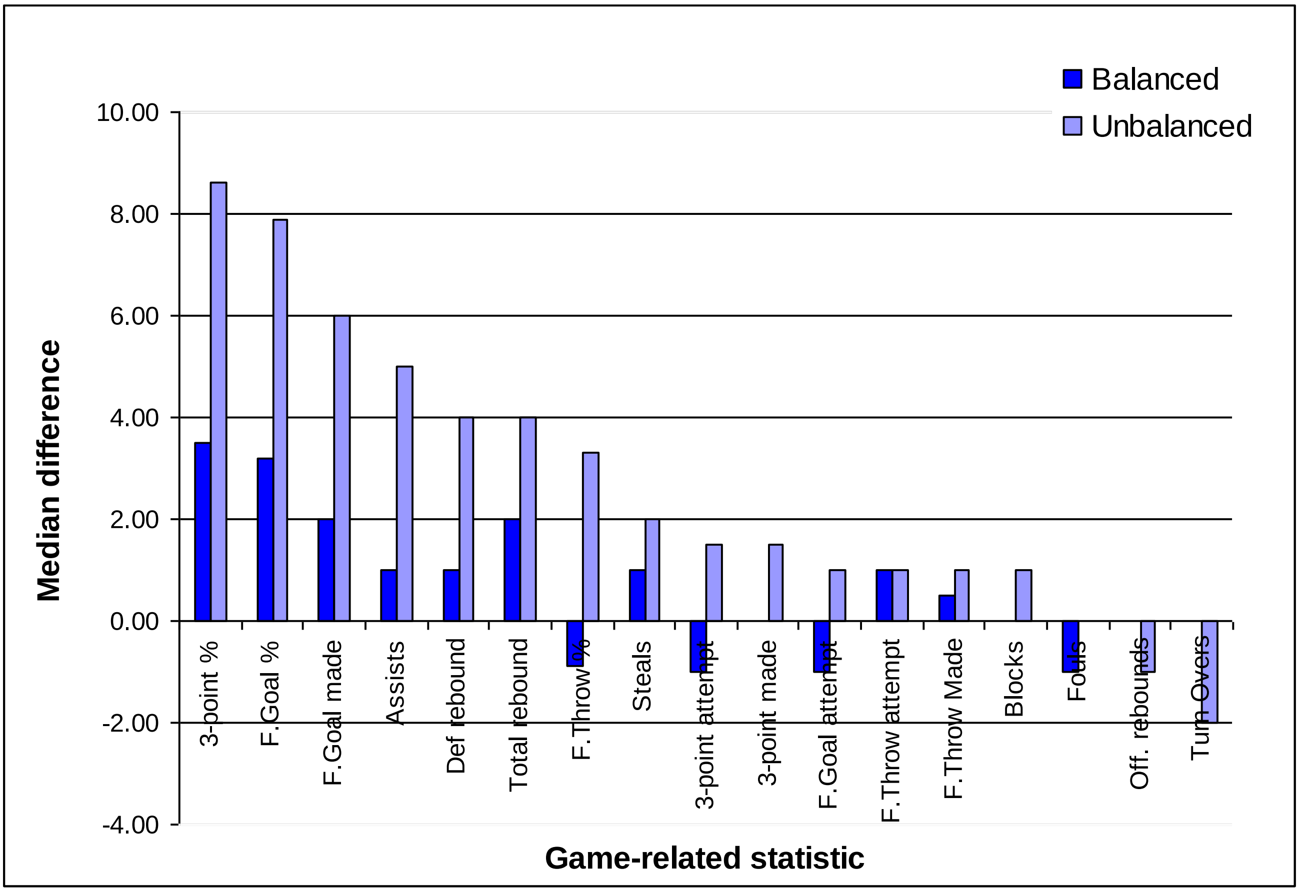

Figure 5: The median differences for each variable between winning and losing teams, across balanced and unbalanced games.

Figure 5 shows that the median differences between the winning and losing teams are generally higher in unbalanced games than in balanced games; apart from offensive rebounds and turnovers. Whilst free throws attempted median difference (+1) is the same for both balanced and unbalanced games. In addition, the majority of variables are higher for winning teams in balanced games, with the exception of; free throw percentage (-0.9), three point attempts (-1), field goal attempt (-1) and fouls (-1) which are all higher in the losing teams (Figure 5). In contrast, offensive rebounds (-1) and turnovers (-2) are the only variables that are higher for losing teams in unbalanced games, whilst the rest are greater for winning teams.

Figure 5, also infers that both significant variables (field goals made and field goal percentage) for balanced games, are greater for winning teams. Whilst for unbalanced games, turn overs (-2) is the only significant independent variable that is greater for losing teams. Thus, field goals made (+6), field goal percentage (+7.9), three points made (+1.5), three point percentage (+8.6), defensive rebounds (+4), total rebounds (+4), assists (+5) and steals (+2) are all significant variables for unbalanced games, that are higher for winning teams.

CHAPTER IV

DISCUSSION

4.0. Discussion

4.1. Reliability and validity

As highlighted in Chapter 1, many performance analysis research papers in basketball present no, or limited assessment of, reliability and validity (Sampaio & Janeira, 2003; Sampaio *et al.,* 2004; Gomez *et al.,* 2008; Krause *et al.,* 2008; Csataljay *et al.,* 2009; Ibanez *et al.,* 2009; Sampaio *et al.,* 2010a; Garcia *et al.,* 2013). Hughes *et al.,* (2004) supports this worrying trend and identified that 70% of presented papers, completed no reliability tests whatsoever. The work of Bland and Altman (1986) has altered the process of research in sport and promoted the testing of reliability and validity, to support key findings associated with the raw data (Hughes *et al.,* 2004; O'Donoghue, 2007; O'Donoghue, 2012).

Reliability is concerned with the identification and quantification of variability in scores between repeated tests (Cooper *et al.,* 2007). Hughes *et al.,* (2001) identified that one of the most popular statistical methods for assessing reliability is percentage errors. However, percentage error "gives a single value describing an average error concealing important information about the range and consistency of error values" (O'Donoghue, 2012, pp. 354). Therefore, this study's procedure for the assessment of reliability was built upon Cooper *et al.'s,* (2007) proposed non parametric 95% limits of agreement. This process of estimating the reliability of raw data was based on the fundamental principle to treat each game-related statistic as an individual item. This allowed the analyst to assess the raw data to the same depth as the subsequent analysis and provide reliability results for each performance indicator separately.

The reliability results highlighted that the agreement between the test and retest scores for the majority of performance indicators was acceptable (Table 7). Three points made and blocks showed perfect agreement in all 48 time cells (100%, Confidence Interval [CI]: 100%), which might suggest that they are the most reliable variables. The lowest recorded result of PA = 0 was 81.3% (CI: 70.3 to 92.3%) for assists, which implies it was the most difficult performance indicator to notate; due to the apparent subjectivity. In addition, three points attempted (97.9%, CI: 93.9 to 100%) and assists (93.7%, CI: 86.9 to 100%) were the only two performance indicators that did not produce 100% when considered in terms of the reference value ±1. Cooper *et al.,* (2007) stated that "90% of the differences between test and retest data should lie within a reference value of ±1" (pp. 106). This further suggests that there is a higher variance between the test and retest scores of three points attempted and assists but not above the recommend limit. Thus, the results imply that all game related variables showed accurate scores with little variation between test and retest. However, defensive rebounds ($P = 0.031$) and turn overs ($P = 0.016$) showed statistical systematic bias ($P < 0.05$) and consequently the analyst can not be considered a reliable source, in terms of defensive rebounds and turnovers.

In addition, O'Donoghue (2012) stated that the measurement issue of validity is also important in sport research, to support the accuracy of raw data and conclusions presented. A study by Choi *et al.,* (2007) aimed to indentify which statistic for assessing agreement was the most appropriate for real-time basketball analysis. The process utilised similar performance indicators than this present study, specifically; field goals attempted, field goals made, three points attempted, three points made, free throws attempted, free throws made, defensive rebounds, offensive rebounds, assists, personal fouls, steals and turnovers were observed in a basketball performance. Choi *et al.,* (2007) "revealed that kappa was the only statistic with construct validity for this type of data" when compared with Pearson's r, chi square and percentage error (pp. 58).

Thus, this present study aimed to assess the criterion-related validity with the kappa statistic, to quantify the accuracy of the official National Basketball Association (NBA) scores. It is important to highlight here that the near perfect similarity of testing procedure and variables, supports claim to the justification of chosen statistic. In addition, Choi *et al.,* (2007) recommends higher agreement thresholds than those originally proposed by Altman (1991) for medical application. The results highlighted that the games between Miami and Boston (0.68), New York and Dallas (0.639) and the combined kappa value (0.662) were above the acceptable limit when compared with Choi *et al.'s* (2007) recommendations. Whilst a comparison with Altman's (1991) medical values for agreement would have suggested a good strength in all games and combined. These findings support claim to the accuracy of data and imply that the agreement between the official NBA scores and the independent analyst is adequate; when considered against both performance analysis and medical parameters.

4.2. All games

The aim of the study was to identify game-related statistics, in terms of performance indicators, that significantly differed between winning and losing teams. After analysing 246 games from the Men's NBA (2012 – 2013) Regular Season, it became clear that this dynamic game produces significant variables associated with the outcome. Noticeably, in all games, eight variables were highlighted as being significantly different between winning and losing teams. These game-related statistics include: field goals made, field goal percentage, three points made, three point percentage, defensive rebounds, total rebounds, assists and turnovers (Table 8).

The analysis allowed the estimation for an average winning and losing team, across each variable to be calculated. This provided a comparison between winning and losing team's median for each game related statistic. It became evident that the winning teams generally produced higher values than that of the losing teams; with the exception of offensive rebounds (-0.5), three points attempted (-1), turn overs (-1) and fouls (-1). Although it is beneficial for teams to produce higher values for some independent variables (more field goals made = more points); this might not be the case for the four performance indicators mentioned above. For instance, in order for a team to complete an offensive rebound, they must first be unsuccessful on an attempted field goal (Ramen, 2007). Thus, indicating that the team's shooting efficiency is poor, which results in fewer points scored and requires reliance on offensive rebounding. In addition, the losing teams produced more three points attempted than that of the winning teams. In basketball the easiest and most efficient way to score points is the use of a lay-up (McGee, 2007). This is the preferred method by teams, which allows players to get closer to the basket and therefore, have greater chance of scoring points (Krause *et al.,* 2008; Rose, 2012). Consequently, the increased value of three points attempted could suggest that the winning teams produced good defence and forced the losing teams to shoot from distance. Thus, increasing the probability to miss these longer, more difficult shots and promote the opportunity for rebounding.

Furthermore, the losing teams also produced higher values of turn-overs than that of the winning teams. A turn-over is a mistake by the attacking team with the ball, which concedes the chance of scoring by that team, provides the opposition with ball possession and ultimately the opportunity to score (Ramen, 2007; NBA Media Ventures LLC, 2013b). The final game related statistic that was evidently higher for losing teams was fouls. These personal fouls can result in free throws being awarded to the opposition. Thus, each foul committed promotes scoring attempts for the opposition and consequently chances to attain points; which will negatively affect the outcome of the game. Therefore, limiting the number of personal fouls is beneficial to team success but not significantly (Sampaio & Janeira, 2003; Csataljay *et al.,* 2009).

4.3. Balanced and unbalanced games

The results of this study also indicated differences between game types (balanced and unbalanced) as highlighted by previous research (Csataljay *et al.,* 2009; Garcia *et al.,* 2013). In this study, balanced and unbalanced games were differentiated based on the difference between the team's final points scored. Specifically, balanced games had a score differential of less than and equal to eight points and unbalanced games greater than eight points. Following the analysis, balanced games produced two significant performance indicators (field goals made and field goal percentage); whilst unbalanced games highlighted nine independent variables in total (field goals made, field goal percentage, three points made, three point percentage, defensive rebounds, total rebounds, assists, turnovers and steals). In balanced games, free throw percentage (-0.9), three points attempted (-1.0), field goals attempted (-1.0) and fouls (-1.0) were greater for losing teams (Table 9). Whilst in unbalanced games, the majority of variables were higher for the winning teams, with the exception of offensive rebounds (-1.0) and turnovers (-2.0).

As previously highlighted, it might be beneficial for a team to produce lower values for three points attempted, fouls, offensive rebounds and turnovers. However, in balanced games, the losing teams also produced higher values for free throw percentage and field goals attempted. This suggests that the number of points scored from free throws or the magnitude of field goal attempts do not contribute to a team winning a game. The statistical analysis supported these conclusions and indicated that free throw percentage and field goal attempts are not significantly different between winning and losing teams ($P < 0.003$). Further suggesting that field goal efficiency in open play is significantly influential to the outcome of a game, as apposed to attempts (Csataljay *et al.,* 2009).

4.4. Field goal efficiency

The fundamental principle associated within competitive basketball is to score points by legally getting the ball through the opposition's hoop (Oliver, 2004; McGee, 2007; Ramen, 2007; Krause *et al.,* 2008). Shooting efficiency refers to the capability of a team to successfully score points from field goals attempted (Wissel, 2004; Rose, 2012). Previous research has identified that good shooting efficiency allows a team to score more points and can significantly enhance the ability to win (Gomez *et al.,* 2008; Ibanez *et al.,* 2009; Csataljay *et al.,* 2009; Sampaio *et al.,* 2010a; Garcia *et al.,* 2013). The results from this study agree with previous findings and infer that good shooting efficiency is influential to success across all three categories (all games, balanced games and unbalanced games). Specifically, field goals made (+4.5), field goal percentage (+5.0), three points made (+1.0) and three point percentage (+5.6) in all games, were significantly different between the winning and losing teams (Table 8). Furthermore, unbalanced games included the same significant shooting performance indicators: field goals made (+6.0), field goal percentage (+7.9), three points made (+1.5) and three point percentage (+8.6). Whilst, balanced games only included field goals made (+2.0) and field goal percentage (+3.2) as being significantly different (Table 9). It is important to highlight that three points made and three point percentage are not significantly different between winning and losing teams in balanced games. This suggests that in closer scoring games, shooting from distance will not benefit nor hinder a team's result.

In addition, it is evident that free throws do not impact the outcome of a game, in any category. Free throws are awarded following a foul, not recorded as field goals and total a single point for successful completion (McGee, 2007; Krause *et al.,* 2008). Thus, a team's shooting efficiency in regards to free throws has limited effect on the final result; due to the restricted contribution to the final score. The results also indicate that the magnitude of attempts to score (field goals attempted and three points attempted) do not impact the outcome of a game but only the successful completion of these attempts (Table 8).

4.5. Rebounding

A rebound refers to the act of acquiring possession immediately after an unsuccessful field goal or free throw (Wissel, 2004; Rose, 2012). The analysis highlighted that the winning teams' defensive rebounds and total rebounds were significantly greater than that of the losing teams, across all games and unbalanced games (Table 9).

However, this trend did not occur in balanced games with only field goals made and field goal percentage being significant. These findings agree with previous research and conclude that winning teams complete more defensive rebounds than that of the losing teams (Gomez *et al.,* 2008; Ibanez *et al.,* 2009; Sampaio *et al.,* 2010a; Garcia *et al.,* 2013).

Defensive rebounds are important in basketball, as they limit the opposition from having repeated second attempts and provide the opportunity for an effective fast break (McGee, 2007; Krause *et al.,* 2008). Consequently, a team's ability to capitalise on a defensive rebound with a fast break is a vital factor to achieve victory (Tsamourtzis *et al.,* 2005). Ibanez *et al.,* (2009) suggested that high level defensive rebounds indirectly rely on three underlying factors; the players somatic characteristics (tall and strong), technical and tactical preparation (pivot, box and secure space) and muscle endurance (repetitive explosive jumping). Therefore, the teams with players that excel in these capabilities will increase there rebounding efficiency and thus, positively and significantly influence the outcome of a game.

4.6. Assists

An assist is credited to a team, when a player passes the ball to a scoring team mate prior to the made field goal (Ramen, 2007; NBA Media Ventures LLC, 2013b). This action is not directly linked to the technical capacity but with the decision and perception process, to read the dynamic game (Oliver, 2004; Garcia *et al.,* 2013). It is based on the understanding of team work and the identification of unison to complete the desired outcome (scoring). Evidently, the number of assists correlates with the number of field goals made; an important aspect in basketball (Csataljay *et al.,* 2009). The analysis highlighted that winning teams significantly produced more assists than the losing teams, in all games (+3.0) and unbalanced games (+3.0). However, in balanced games, assists showed little variation between winning and losing teams (Table 9). Thus, suggesting that in balanced games there is less reliance on team work to win and more emphasis on individuals to create their own chances to score.

Sampaio *et al.,* (2004) supports these findings and identified that less experienced teams produced a lower percentage of assists than more experienced, elite teams. This study suggests that winning teams might have developed a higher team maturity and ability to read defences, than that of the less able, losing teams. In addition, Lyons *et al.,* (2006) and Royal *et al.,* (2006) identified that higher levels of physical fitness will maintain the accuracy of passing and contribute to continued effective decision making. Thus, teams could significantly influence the outcome of a game through successful completion of assists aided by fitness levels.

4.7. Turn overs and steals

A turn over in basketball is widely regarded as a negative mistake that results in the loss of possession (Krause *et al.,* 2008; NBA Media Ventures LLC, 2013b). In contrast, a steal is positive and refers to the ability to obtain possession from the attacking opposition (McGee, 2007). Consequently, a turn over prevents the chance to score and provides the opposition with an opportunity; whilst a steal promotes the opposite (Rose, 2012). Therefore, it could be presumed that teams want to limit turn overs and maximise steals, due to the associated consequences (Gomez *et al.,* 2008). The analysis supports this theory and highlighted that across all games the winning teams produced less turnovers (-1.0) and significantly more steals (+1.0) than that of the losing teams (Table 8). It is important to highlight that although turnovers were non significant for all games, the number of turnovers correlates with the number of steals; every steal credits a turn over (Appendix A; NBA Media Ventures LLC, 2013b). Subsequently, when unbalanced games were considered separately, both turnovers (-2.0) and steals (+2.0) were significantly different between the wining and losing teams (Table 9).

In addition, Fylaktakidou *et al.,* (2011) highlighted that 40% of turnovers in basketball are passing errors, most occurring particularly in set plays. Thus, the ability of a team to perform set plays with high passing accuracy will, consequently, decrease their probability of a turn over and significantly impact the outcome of a game (Sampaio *et al.,* 2004; Fylaktakidou *et al.,* 2011). A player’s capability to steal the ball relies heavily on good anticipation, explosive timing, reaction times and the ability to read the game (Wissel, 2004). Therefore, teams should focus on these defensive characteristics to increase the number of steals and significantly influence the outcome of a game.

4.8. Implications

The underlying issue associated with the examination of game-related statistics in basketball, is that of external validity (Bracht & Glass, 1968; Sampaio *et al.,* 2006). Differences in game rules, playing positions and styles of play between basketball leagues support the idea to reject the generalisation of findings to the entire basketball population (Bracht & Glass, 1968; Sampaio *et al.,* 2006). Thus, the conclusions from this study can only be applicable to professionals associated with the National Basketball Association. However, the results did highlight important variables that coincide with studies concluded on various leagues across the world; in particular, defensive rebounding and most evidently shooting efficiency (Gomez *et al.,* 2008; Krause *et al.,* 2008; Csataljay *et al.,* 2009; Ibanez *et al.,* 2009; Sampaio *et al.,* 2010a; Garcia *et al.,* 2013). This study's resulting conclusions can have numerous practical applications for a basketball team's support staff. Specifically, the coach can utilise the findings within tactical and team selection, coaching practice and recruitment process.

4.8.1. Coaching practice

The fundamental aim of a coach is to prepare a team for the required game conditions and promote the ability to win (Lyle, 2002; Wissel, 2004). In order for a coach to prepare a team, they must first acquire the necessary knowledge of the game and future opponents (Ramen, 2007). Thus, the coaches in the NBA could use the results of this study to direct the training focus and enhance the aspects proven to significantly affect the outcome. As previously highlighted, field goal efficiency, defensive rebounding and turn overs have a significant effect on the outcome of a game, in all games (Table 9). Evidently, the coach should set drills within training that will enhance both two and three point field goal efficiency. However, the analysis indentified that free throws do not significantly affect the outcome of a game and therefore, practice time should be limited to enhance this aspect of performance.

As previously mentioned Ibanez *et al.,* (2009) suggested that players who excel in the technical and tactical aspects of rebounding will ultimately be more successful. Therefore, coaches should place a greater emphasis on the enhancement of rebounding technique. In addition, specific strength and conditioning programmes designed to enhance muscular endurance will promote rebounding ability and ultimately impact the outcome of a game (Ibanez *et al.,* 2009). Fylaktakidou *et al.,* (2011) highlighted that passing inaccuracy in set plays was the most occurring turn over error in a basketball game. Therefore, to limit the number of turnovers and augment the chance of victory, a coach could aim to enhance passing ability in pressure situations; specifically within set plays.

Furthermore, the findings from this study could be used to inform player selection before and during a game; through substitution. It is evident that teams require players with good shooting efficiency and defensive rebounding to be successful. However, the evidence suggests that in balanced games, teams do not need: three point specialists, players that can steal the ball or defensive rebounders but rely solely on high shooting efficiency. In contrast, teams in unbalanced games require a greater variety of playing aspects in the players (Table 9). In particular, players that: display good team work capabilities (assists), are able to read the game (steals) and have good passing accuracy in set plays (turnovers). Ultimately, the coach can substitute a player on that is more superior at the significant variable that the situation demands.

4.8.2. Recruitment process

The findings produced not only aimed to inform coaches on player selection (squad, team line-up or substitutes) but they can also aid scouts in the player recruitment process. Currently, scouts in the NBA utilise statistical player history on individuals, along with live observation on which to base recruitment decisions (NBA Media Ventures LLC, 2013b). Understanding the key game-related statistics that influence the outcome of a game will highlight desired player characteristics. The identification of these characteristics or required player traits will build a foundation for scouts to assess potential players. Thus, the results suggest that scouts should prioritise shooting efficiency, rebounding effectiveness, assists and turn over data, above any other performance indicators. For instance, if a scout is forced to make a decision between two players of equal ability but the statistics show that one has superior shooting efficiency and the other higher block success rate; then the scout should chose the efficient shooter. In addition, player recruitment can also take into account physiological aspects associated with significant performance indicators. In particular, defensive rebounding favours the tall and strong player with wide hips and high muscular endurance (Ibanez *et al.,* 2009). Consequently, scouts could use isoperformance curves to “define combinations of two or more physiological attributes of individuals” and compare them to different players in the decision making process (Morton, 2009, pp. 1602).

4.8.3. Tactics

Tactics are based on the fundamental idea to utilise a team's strengths against the opponents' weaknesses (Rose, 2012). It has been acknowledged that coaches have the freedom to choose whether to base game tactics on players or player selection on predefined tactics (Trninić *et al.,* 2008). However, Garcia *et al.,* (2013) recommended that coaches should establish game strategies to achieve better values of the significant performance indicators. This suggests that player selection and game tactics ought to be based on the sole intention to enhance the significant game-related variables. Therefore, for game preparation the focus should be on two and three point shooting efficiency, enhancing defensive rebounding and assists, whilst limiting turnovers. Similarly, for unbalanced games the tactics and player selection should be maintained from the start (game preparation) but with more emphasis on steals. In contrast, when the game is balanced the focus should be solely on promoting two point field goal shooting efficiency. However, it is important to highlight here that these recommendations are based on statistical assumptions and do not take into account human processing, opposition effect or game rhythm contamination (Sampaio & Janeira, 2003; Sampaio *et al.,* 2010b).

CHAPTER V

CONCLUSION

5.0. Conclusion

It has been acknowledged that researches should demonstrate the reliability of a system clearly and assess the raw data to the same depth as the subsequent analysis (Hughes *et al.,* 2004). Evidently, this paper provided sufficient reliability and validity tests to assess the accuracy and truthfulness of the raw data. The reliability analysis highlighted that for each variable, 90% of the differences between test and retest data was within a reference value of ±1. Although the findings produced good agreement across all variables; defensive rebounds (P = 0.031) and turn overs (P = 0.016) showed statistical systematic bias (P < 0.05). Therefore, the data analysis results for turn overs and defensive rebounds exclusively, should be tempered to the fact of this poor reliability and subsequent conclusions formed are restricted to this limitation. The study also assessed the criterion-related validity to quantify the accuracy of the official NBA scores. The combined kappa value (0.66) was within the acceptable band of agreement and therefore, supports claim to the accuracy of raw data used.

In conclusion, the analysis of 246 games from the 2012-2013 National Basketball Association (NBA) Regular Season, identified that there are certain game-related statistics that significantly discriminate between winning and losing teams. Overall, field goals made, field goal percentage, three points made, three point percentage, defensive rebounds, total rebounds, assists and turn overs significantly influence the outcome of a game. The comparison between balanced and unbalanced games further highlighted that there were evident differences, in terms of important variables. In particular, the analysis indentified that unbalanced games (nine) produced more significant performance indicators than balanced games (two). Consequently, balanced games rely solely on two point shooting efficiency to influence the outcome. In contrast, three point shooting efficiency, rebounds, assists, steals and turn overs also became discriminative in unbalanced games. In addition, the difference between winning and losing teams for each variable is generally higher in unbalanced games.

The findings from this study and consequential knowledge, produces many practical applications for coaches and scouts in the NBA. The identification of the specific required skills that underlie high performance, enables coaches to; design conditioning programs, regulate training sessions and inform player and tactical selection to target these fundamental elements. Consequently, coaches should: (1) aim to enhance player’s muscular endurance, to maximise rebounding effectiveness; (2) develop two and three point shooting efficiency, as apposed to free throw; (3) encourage co-operation and team work, to increase possible assists; and (4) improve passing accuracy in set plays, to limit unwanted turn overs. Moreover, the contrasting results between balanced and unbalanced games can be used to inform coaches on the most effective strategy in a given situation; thus making tactical or substitution changes accordingly. In addition, the findings can inform scouts on the desired player characteristics that will maximise the effectiveness to win. Specifically, the study indentified and constructed a desired performance player profile based on the significant variables, which scouts could utilise as a framework for assessment or comparison. For instance, shooting efficiency and defensive rebounding were significant variables associated with the outcome of a game. Thus, scouts should aim to recruit players that excel in these significant and evidently, game-changing elements.

5.1. Areas for development and future research

The effective utilisation and analysis of game-related statistics can be beneficial to the specific basketball community on which it was concluded; if the findings produced are supported with adequate reliability and validity procedures. As a limitation, the study was only concluded on a 20% sample of the NBA regular season and future research could investigate the entire season for strengthened results. In addition, the present study did not take into account Game Rhythm Contamination (GRC), in terms of team ball possession; due to the inability to obtain the required ball possession data. Consequently, future research should normalise the values to 100 ball possessions to eliminate GRC and provide the ability to compare the results with other studies (Garcia *et al.,* 2013). Furthermore, Sampaio *et al.,* (2006) highlighted that performance and rules in the NBA are different to European leagues, as highlighted in Chapter 1. Thus, this study and the findings are only specific to the NBA and can not be generalised to the entire basketball population. Therefore, future research should replicate the present study on different leagues of interest to support the specificity of results.

Furthermore, the validity assessment was completed on limited games within the sample (0.81%) and did not assess the game-related variables as individual items. Future studies should, therefore, include a greater percentage for evaluation and where possible assess the validity of each individual variable for improved analysis. Evidently, quantitative analysis on basketball is not always enough to fully understand the game and ultimately qualitative complementary analysis is also required to further investigate significant variables (O’Donoghue, 2007; Garcia *et al.,* 2013). Thus, future research could qualitatively analysis the significant performance indicators and associated variables highlighted within this study.

To conclude, the focus of this study was on the investigation into the discriminatory power of game-related statistics within the NBA. Consequently, the procedure highlighted key performance indicators that influence the outcome of a game and included an in-depth assessment of both reliability and validity to support these findings. However, the final thought of this study should really echo the beliefs of Hughes *et al.,* (2004) and Cooper *et al.,* (2007); where the normalisation of these reliability and validity procedures for performance analysis research should be applied, to provide accurate, valid and trustworthy conclusions.

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APPENDICES

APPENDIX A

GAME-RELATED STATISTICS & OPERATIONAL DEFINITIONS

Table A1: All observed game-related statistics with appropriate operational definitions (Oliver, 2004; McGee, 2007; Ramen, 2007; NBA Media Ventures LLC, 2013b).

Game-related statistic	Definition
Field goals made	A legal field goal scored when the ball, from any playing area, enters the basket from above and passes through the net.
Field Goals Attempted	A shot attempt at the opposition's basket from any playing area, in game time. The shot may or may not be successful; but intended action counted.
Three Points Made	A successful field goal from the area outside the three point field goal line. The shooter does not touch the floor on or inside the three point field goal line prior to ball release from hands.
Three Points Attempted	A field goal attempted from the area outside the three point field goal line. The shooter does not touch the floor on or inside the three point field goal line prior to ball release from hands. The shot may or may not be successful; but intended action counted.
Free Throws Made	A legal goal scored when the ball enters the basket and goes through the net on a sanctioned free throw by the referee. No part of the shooters body can touch or cross the free throw line.

Free Throws Attempted	An attempt to score a sanctioned free throw that was awarded by the referee; the shot may or may not be successful; but intended action counted.
Offensive Rebounds	A player gains possession of the ball after it has rebounded from the opposition's basket or backboard. The last point of contact with the ball must be the board or basket rim.
Defensive Rebounds	A player gains possession of the ball after it has rebounded from their basket or backboard. The last point or contact must be the backboard or basket rim.
Assists	A pass to a teammate, that results in a successful field goal by that player. The assist is only attributed to the player that passes the ball directly before the score.
Steals	A defensive player legally and purposely causes a turnover, which obtains possession for their team.
Blocks	A defensive player successful deflects a field goal attempt, whilst the ball is travelling upward towards the basket.
Turn Over	An offensive player loses possession of the ball which results in the opposition gaining possession. Also accredited when the opposition steals the ball.
Personal fouls	A player violates the rules through illegal physical contact, which requires the referee to award a personal foul.

APPENDIX B

THREE POINTS ATTEMPTED

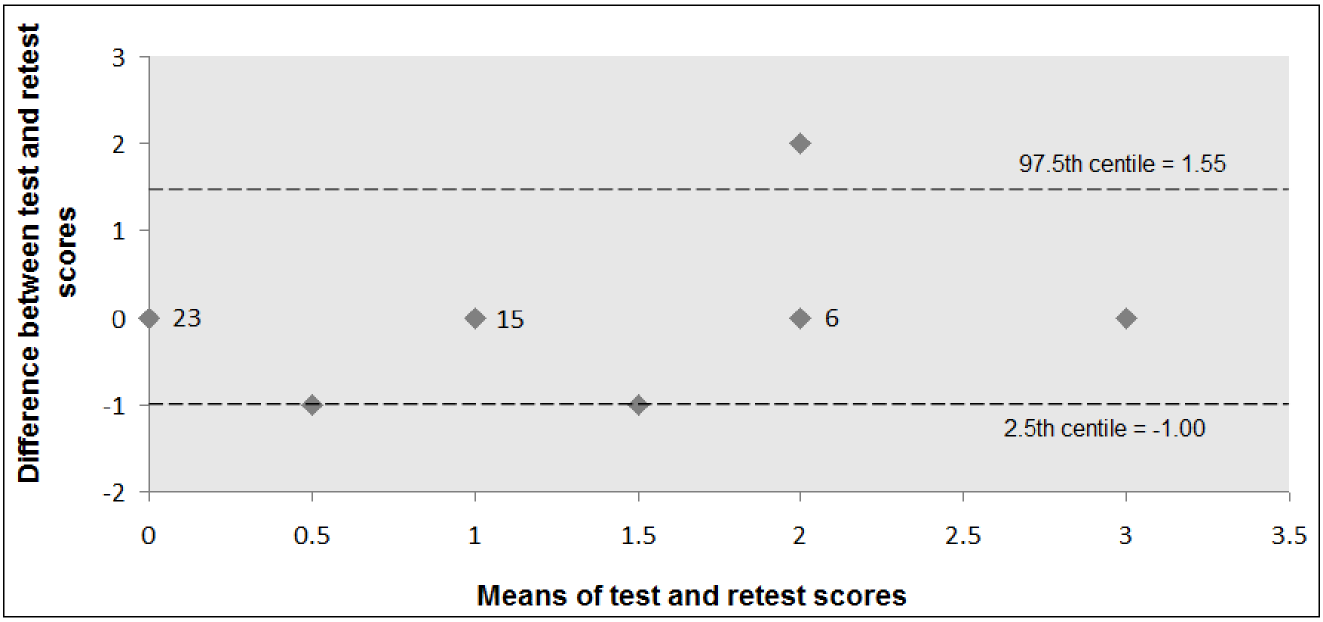

Figure B1: Bland and Altman plot representing the test and retest results for three points attempted. The non-parametric 95% limits of agreement (----------) are superimposed on the plot. Points identified as ' ◆x' portray the number of data points on that co-ordinate.

Table B1: Three points attempted cell frequency and percentage distribution

Difference	Frequency	Percentage
-1	2	4.2
0	45	93.8
1	0	0
2	1	2.1
Total	48	100

APPENDIX C

THREE POINTS MADE

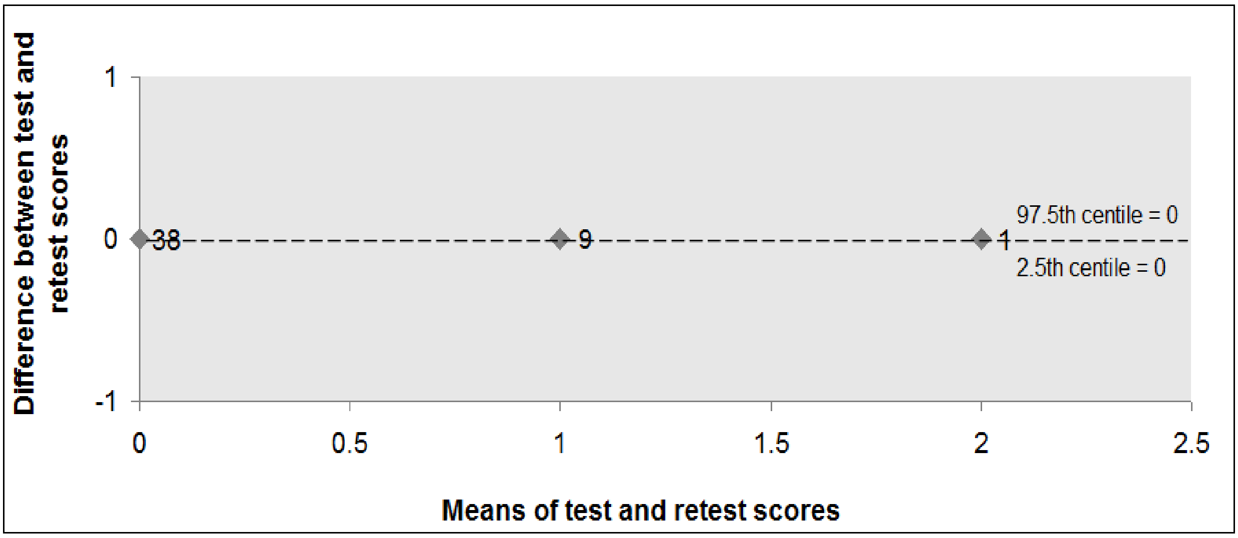

Figure C1: Bland and Altman plot representing the test and retest results for three points made. The non-parametric 95% limits of agreement (‒ ‒ ‒ ‒ ‒ ‒ ‒ ‒ ‒ ‒) are superimposed on the plot. Points identified as '◆x' portray the number of data points on that co-ordinate.

Table C1: Three points made cell frequency and percentage distribution

Difference	Frequency	Percentage
-1	0	0
0	48	100
1	0	0
Total	48	100

APPENDIX D

FREE THROWS ATTEMPTED

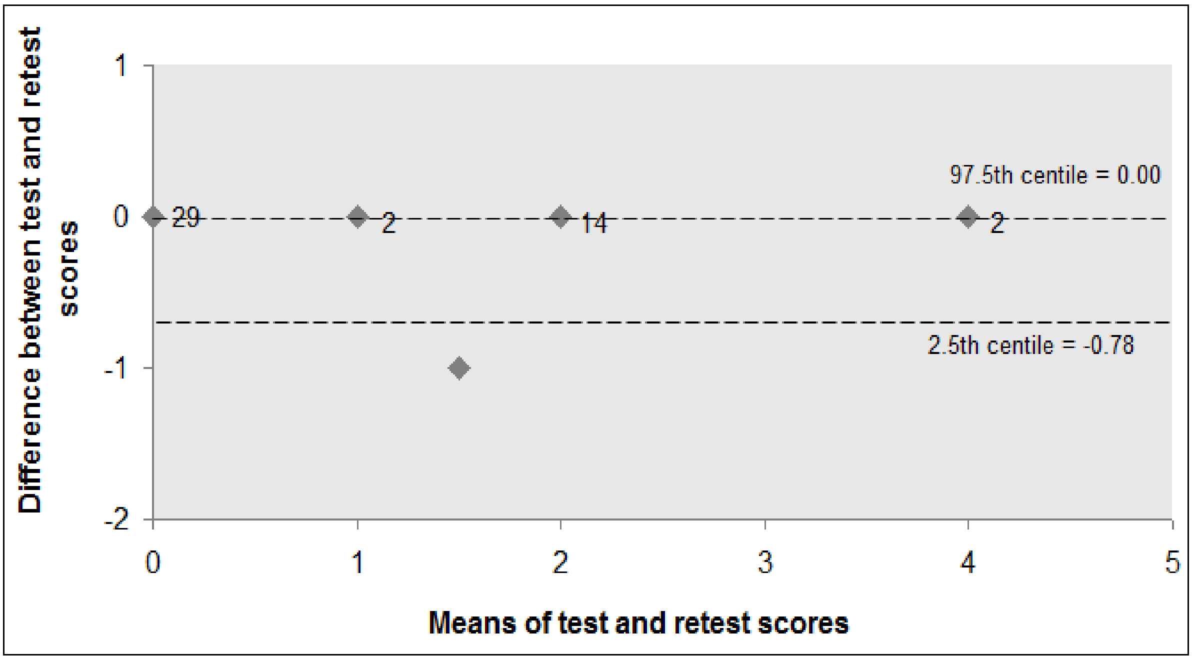

Figure D1: Bland and Altman plot representing the test and retest results for free throws attempted. The non-parametric 95% limits of agreement (_ _ _ _ _ _ _ _ _ _) are superimposed on the plot. Points identified as '◆x' portray the number of data points on that co-ordinate.

Table D1: Three points attempted cell frequency and percentage distribution

Difference	Frequency	Percentage
-1	1	2.1
0	47	97.9
1	0	0
Total	48	100

APPENDIX E

FREE THROWS MADE

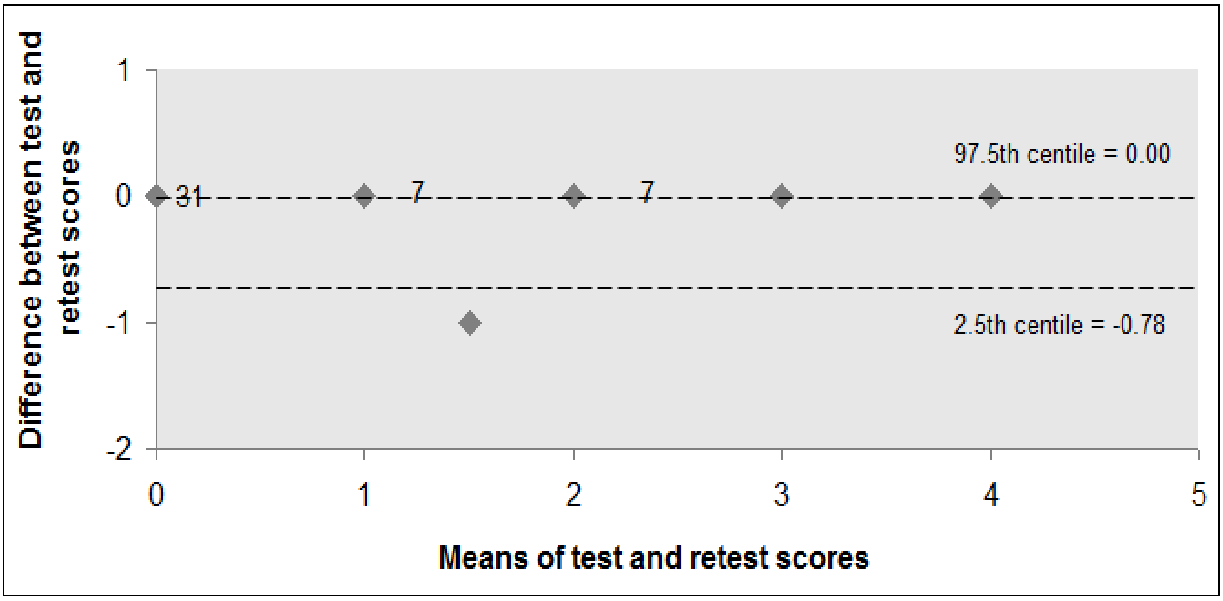

Figure E1: Bland and Altman plot representing the test and retest results for free throws made. The non-parametric 95% limits of agreement (_ _ _ _ _ _ _ _ _ _) are superimposed on the plot. Points identified as '◆x' portray the number of data points on that co-ordinate.

Table E1: Free throws made cell frequency and percentage distribution

Difference	Frequency	Percentage
-1	1	2.1
0	47	97.9
1	0	0
Total	48	100

APPENDIX F
OFFENSIVE REBOUNDS

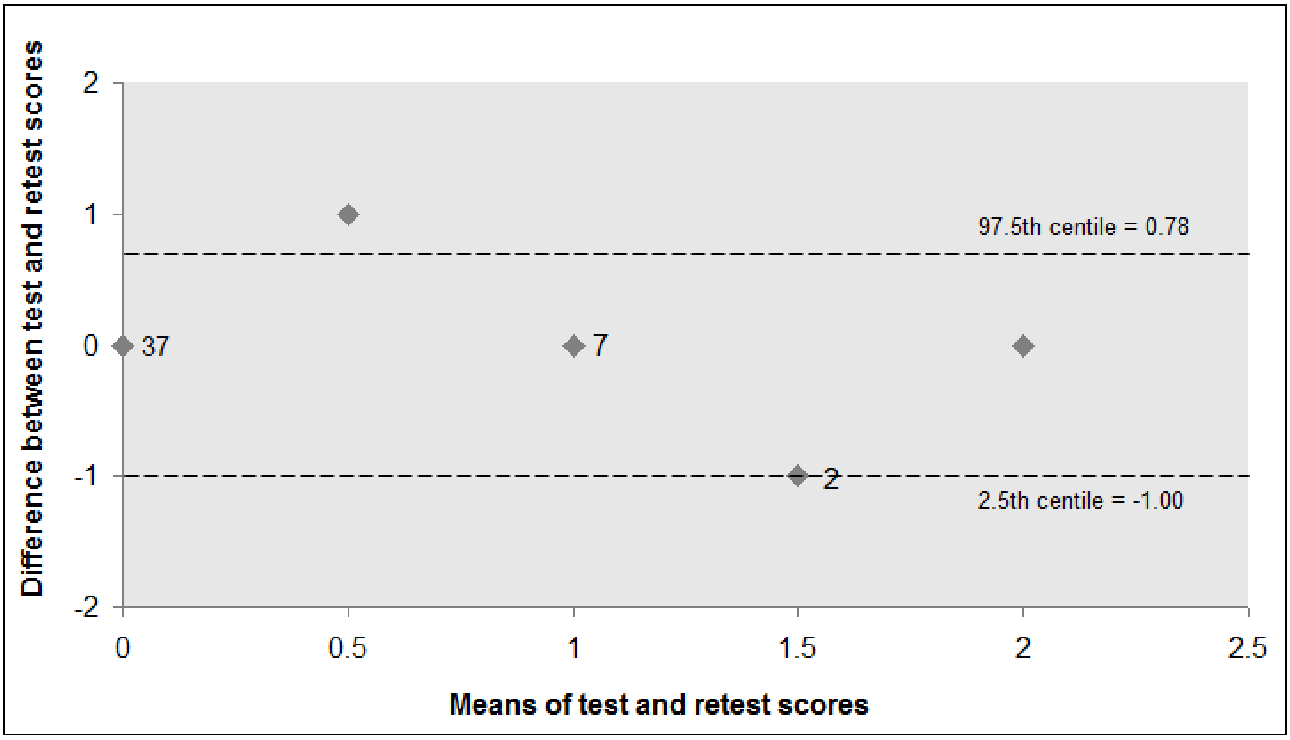

Figure F1: Bland and Altman plot representing the test and retest results for offensive rebounds. The non-parametric 95% limits of agreement (-----------) are superimposed on the plot. Points identified as ' ◆x' portray the number of data points on that co-ordinate.

Table F1: Offensive rebound cell frequency and percentage distribution

Difference	Frequency	Percentage
-1	2	4.2
0	45	93.8
1	1	2.1
Total	48	100

APPENDIX G
DEFENSIVE REBOUNDS

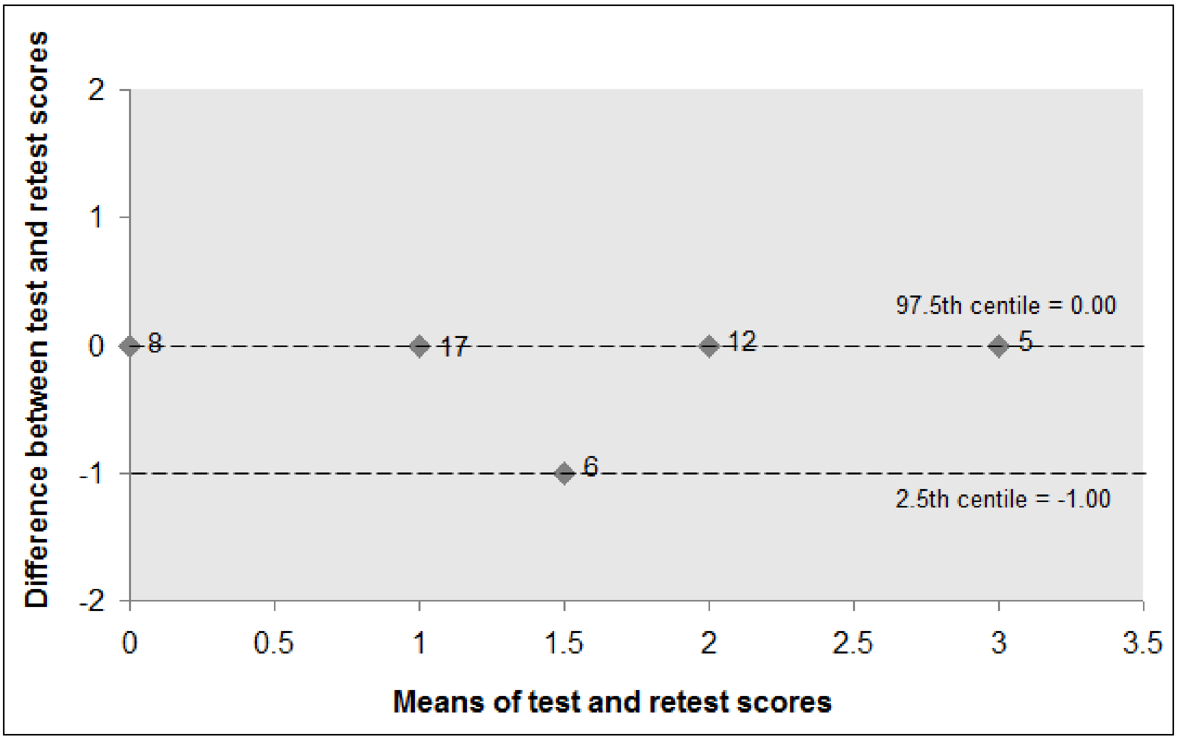

Figure G1: Bland and Altman plot representing the test and retest results for defensive rebounds. The non-parametric 95% limits of agreement (–––––––––––) are superimposed on the plot. Points identified as '◆x' portray the number of data points on that co-ordinate.

Table G1: Defensive rebound cell frequency and percentage distribution

Difference	Frequency	Percentage
-1	6	12.5
0	42	87.5
1	0	0
Total	48	100

APPENDIX H

ASSISTS

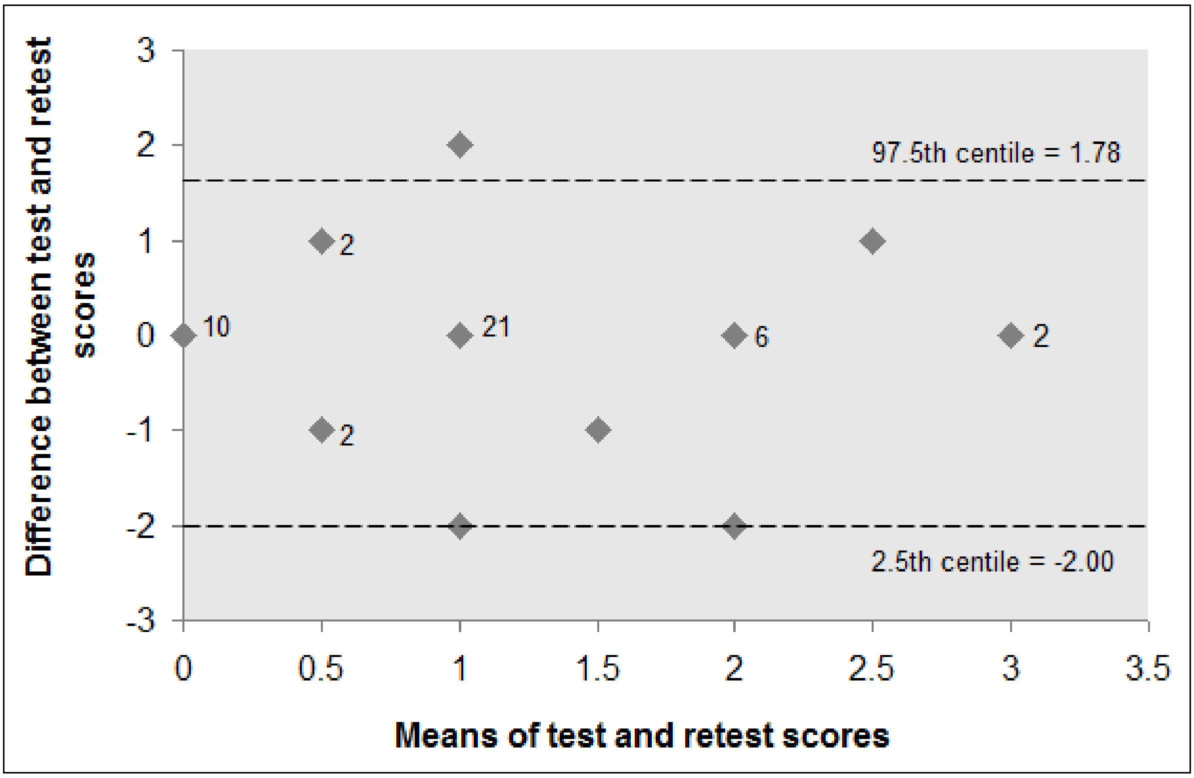

Figure H1: Bland and Altman plot representing the test and retest results for assists. The non-parametric 95% limits of agreement (----------) are superimposed on the plot. Points identified as '◆x' portray the number of data points on that co-ordinate.

Table H1: Assists cell frequency and percentage distribution

Difference	Frequency	Percentage
-2	2	4.2
-1	3	6.3
0	39	81.3
1	3	6.3
2	1	2.1
Total	48	100

APPENDIX I

STEALS

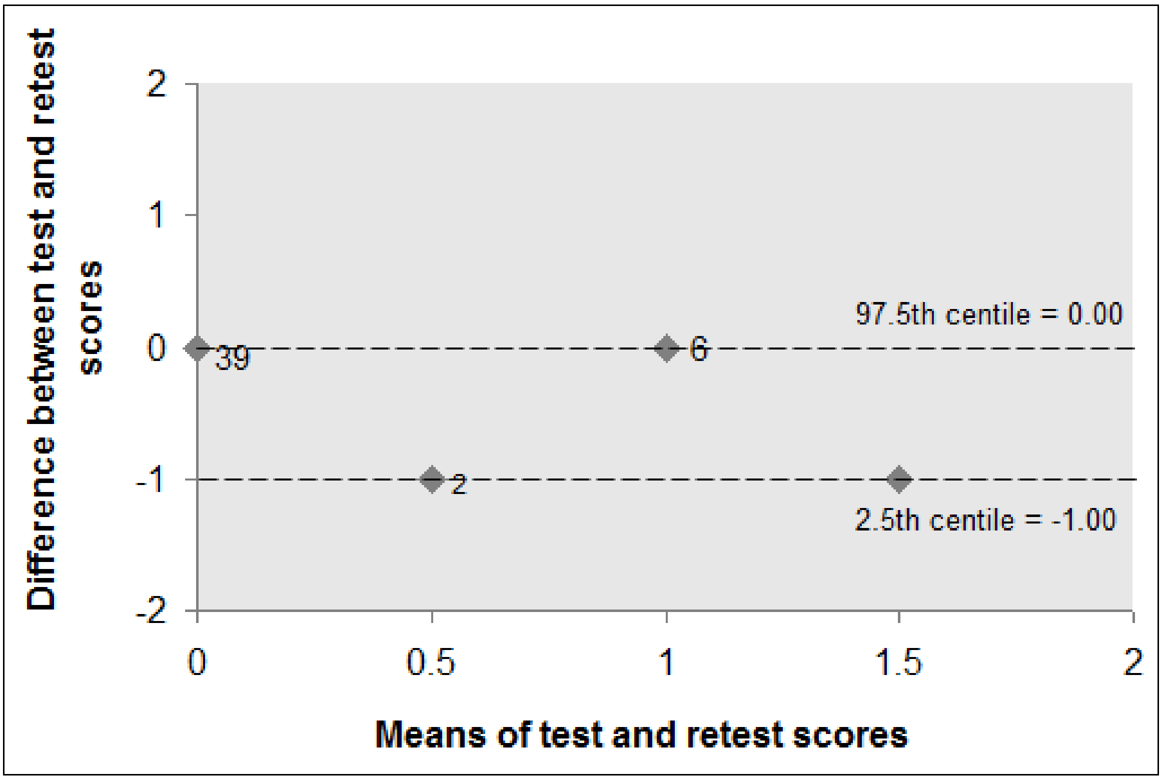

Figure I1: Bland and Altman plot representing the test and retest results for steals. The non-parametric 95% limits of agreement (- - - - - - - - - -) are superimposed on the plot. Points identified as '◆x' portray the number of data points on that co-ordinate.

Table I1: Steals cell frequency and percentage distribution

Difference	Frequency	Percentage
-1	3	6.3
0	45	93.8
1	0	0
Total	48	100

APPENDIX J

BLOCKS

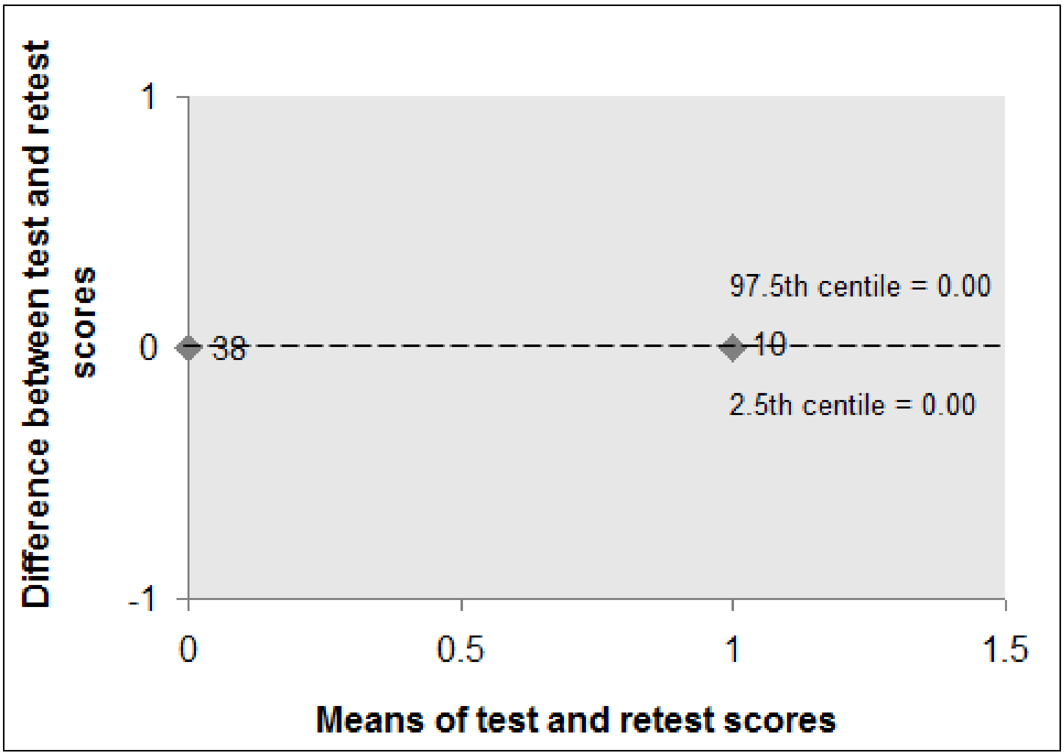

Figure J1: Bland and Altman plot representing the test and retest results for blocks. The non-parametric 95% limits of agreement (__________) are superimposed on the plot. Points identified as '◆x' portray the number of data points on that co-ordinate.

Table J1: Blocks cell frequency and percentage distribution

Difference	Frequency	Percentage
-1	0	0
0	48	100
1	0	0
Total	48	100

APPENDIX K

TURN OVERS

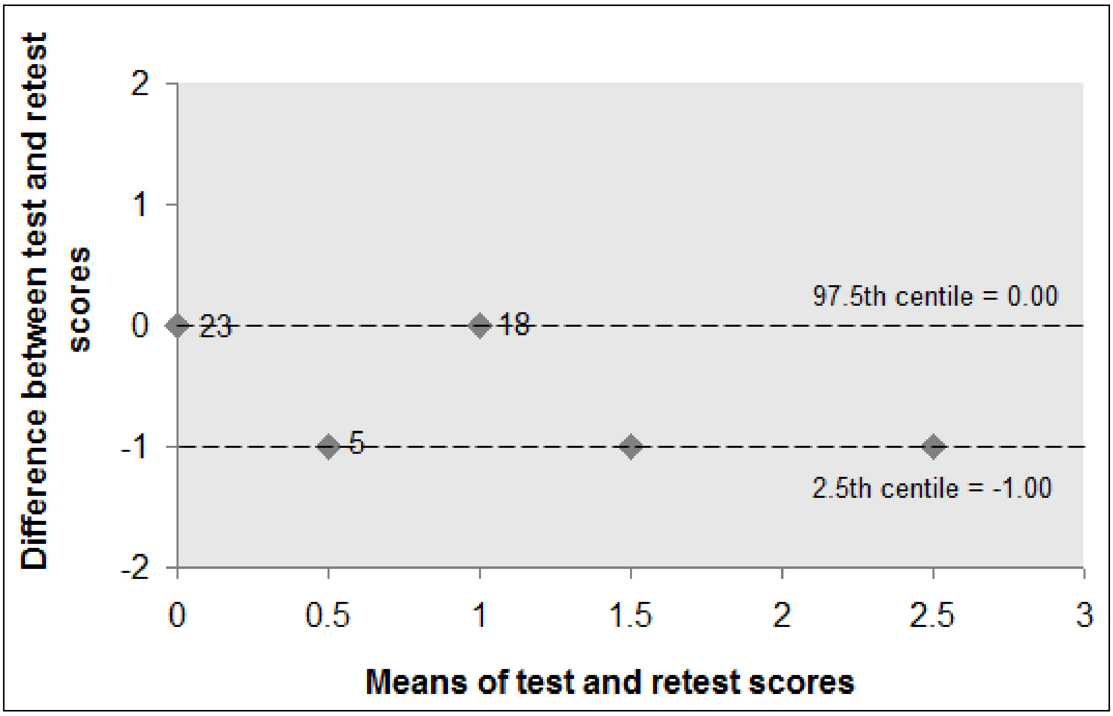

Figure K1: Bland and Altman plot representing the test and retest results for turn overs. The non-parametric 95% limits of agreement (_ _ _ _ _ _ _ _ _ _) are superimposed on the plot. Points identified as ‘ ◆x’ portray the number of data points on that co-ordinate.

Table K1: Turn overs cell frequency and percentage distribution

Difference	Frequency	Percentage
-1	7	14.6
0	41	85.4
1	0	0
Total	48	100

APPENDIX L

PERSONAL FOULS

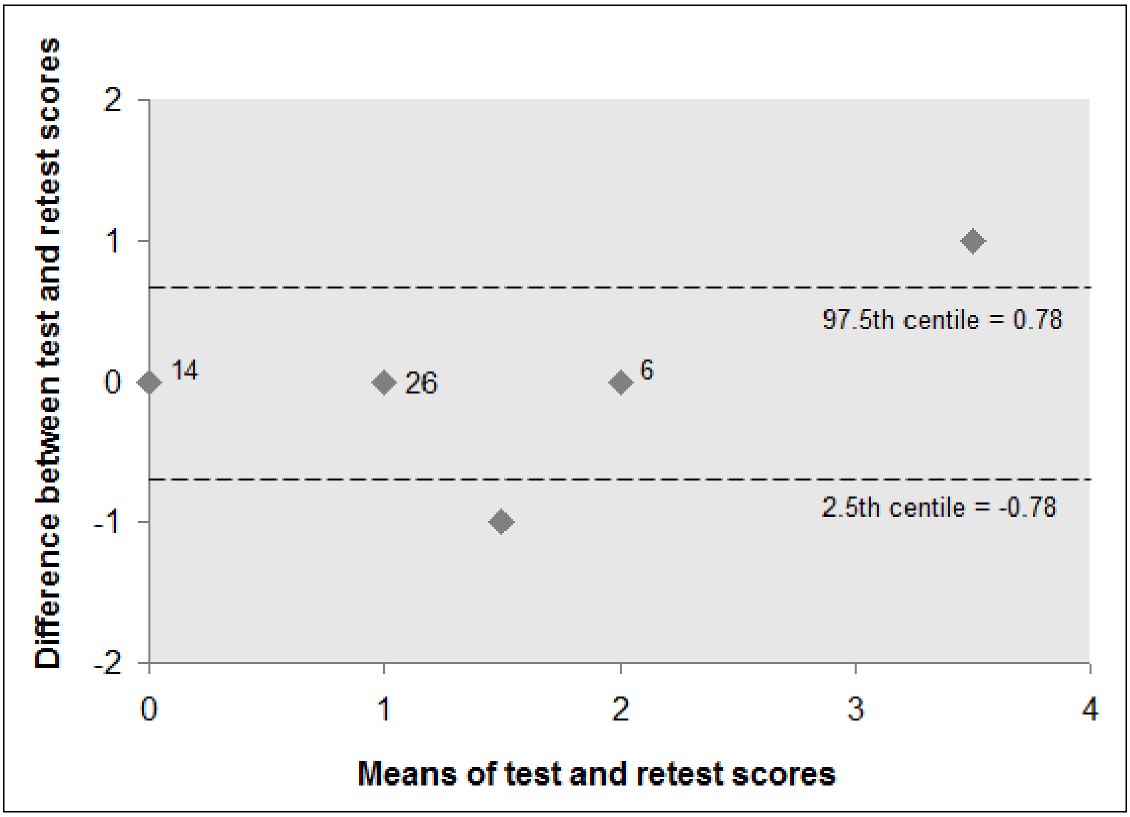

Figure L1: Bland and Altman plot representing the test and retest results for personal fouls. The non-parametric 95% limits of agreement (__________) are superimposed on the plot. Points identified as ' ◆x' portray the number of data points on that co-ordinate.

Table L1: Personal fouls cell frequency and percentage distribution

Difference	Frequency	Percentage
-1	1	2.1
0	46	95.8
1	1	2.1
Total	48	100

APPENDIX M

ETHICS STATUS

Cardiff Metropolitan University | Prifysgol Metropolit Caerdydd

February 6th 2014

Student name: **Mr Peter Lewis Westerman**

Student reference number: **st20001604**

Your project was recommended for approval by myself as supervisor and formally approved at the Cardiff School of Sport Research Ethics Committee meeting of October 16th 2013.

Yours sincerely

Dr Stephen-Mark Cooper FHEA, FRSS (Supervisor)

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