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DISSERTATION ASSESSMENT PROFORMA:

Empirical [1]

Student name:	Emily Jeanne Hurley	***Student ID:***	20018495
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Supervisor:	Lucy Holmes		

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).
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	future developments building on the study; and a conclusion which summarises the relationship between the research question and the major findings.
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ANALYSIS OF SERVICE PLACEMENT WITHIN ELITE TENNIS

(Dissertation submitted under the Performance Analysis area)

EMILY JEANNE HURLEY

ST20018495

ANALYSIS OF SERVICE PLACEMENT WITHIN ELITE TENNIS

Cardiff Metropolitan University
Prifysgol Fetropolitan Caerdydd

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Table of Contents:

List of Tables

List of Figures

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Abstract

The service is the most important and influential stroke in tennis. Performing accurate and consistent serves has been shown to be a key indicator of successful performances. Previous research has examined service placement comparisons in terms of right and left handed players and court surfaces, however the differences between genders and 1st to 2nd serves has been neglected. The aim of this study was to therefore examine service placement in relation to gender differences and comparing 1st to 2nd serves. The data from 248 singles matches from Wimbledon 2014 was analysed and a Mann-Whitney U test was applied to determine statistical significant differences. Analysis revealed significant differences between both genders and 1st to 2nd serve in regards to ball placement within Zones 1 and 3 ($p < 0.001$). This could be attributed to both the greater speed with which men hit service balls and the speed differences between 1st serve and 2nd service ball deliveries, thus making the ball harder to return and therefore points are more likely to be won by men or through a 1st serve. Zone 1 was found to be the most favourable placement for percentage of points won; contradicting previous research that identified Zone 3. Differences in aims and sample sizes could provide explanation for this, so conclusive evidence cannot be drawn without future research being undertaken which takes into account variables examined in both studies.

CHAPTER 1

INTRODUCTION

All racket sports involve short bursts of high intensity exercise due to their intermittent nature (Kovacs, 2007). The highest profile racket sport is tennis, due to the four Grand Slams which are held each year (O'Donoghue and Brown, 2008). Matches at these competitions usually last anywhere between 1 to 5 hours (Torres-Luque, Cabello-Manrique, Hernández-García and Garatachea, 2011) and players will use a combination of tennis strokes in rallies in order to try and win the match. There are five key tennis strokes which are used: the backhand, forehand, serve, smash and volley. Due to the serve starting each point (Matsuzaki, 2004; Tanabe and Ito, 2007), which makes it the only stroke over which players have full control over the outcome (Bahamonde, 2000; Chow *et al*., 2003; Bonnefoy, Slawinski, Leveque, Riquet and Miller, 2009; Kolbinger and Lames, 2013; Sakurai, Reid and Elliott, 2013), it is regarded by many researchers as the most important stroke in elite tennis (Jones, 1986; Pestre, 1998; Cahill, 2002; Matsuzaki, 2004; Johnson, McHugh, Wood and Kibler, 2006; Girard, Eicher, Micallef and Millet, 2010; Reid, Whiteside and Elliott, 2011). Successful serves are those for which the server stands behind the baseline on either the right or left side, with their racket making contact with the ball at around 2.47m from the ground (Trabert and Hook, 1984; Brody, 1987; Vaverka and Cernosek, 2007). This increases the chances of a legal serve, where the ball travels over the net and lands in the opposite diagonal service box to where the server is standing (Chow *et al*., 2003; Matsuzaki, 2004). Players want to serve as many legal serves as possible to maximize the number of points they will win as a server (Furlong, 1995; O'Donoghue and Ballantyne, 2004), giving them an advantage over their opponent (Bahamonde, 2000; Vaverka and Cernosek, 2013).

Two of the most significant outcomes of the serve are the ace and the double fault. Aces are un-returnable serves whilst double faults occur when neither the 1st or 2nd serve lands in (Chow *et al*., 2003). Maximising the number of aces and minimising the number of double faults per game is very advantageous for a player to be successful (Ma *et al*., 2013). For each point the server gets two attempts to try and perform a legal serve, whilst trying to aim each serve in a position that is difficult for their opponent to return (Unierzyski and Wieczorek, 2004; O'Donoghue and Brown, 2009). 1st serves can be hit at speeds 30 km / hr faster than 2nd serves and are therefore much more powerful (Bahamonde, 2000; Girard, Eicher, Micallef and Millet, 2010). 2nd serves focus on accuracy rather than speed by utilising both sidespin and topspin (Trabert and Hook, 1984; Douglas, 1992; Groppel, 1992; Chow *et al*., 2003) and aim to ensure fewer double faults for the server (Patterson, 1964; Filipčič, Filipčič and Berendijaš, 2008). In order to be successful, a players goal is to hit more efficient legal serves than their opponent, increasing the number of points won off the serve (Haake, Chadwick, Dignall, Goodwill and Rose, 2000; Tanabe and Ito, 2007; Filipčič, Filipčič and Berendijaš, 2008).

The purpose of this study is to identify any differences in service positioning between genders and 1st to 2nd serves at Wimbledon. The proposed study will aim to discover if men and ladies have the same service positioning and how often these positions allow them to go on and win the point at Wimbledon. The zonal positions of 1st and 2nd serves will also be examined to determine any statistical differences between the two. The hypothesis is that men will win more points off their serve than ladies and also that players will win more points off their 1st serve than their 2nd serve. It is also suggested that less serves will be won from Zone 2 than from Zones 1 and 3.

CHAPTER 2

LITERATURE REVIEW

Tactical Analysis

Performance analysis as a subject is completely different from other disciplines in that it uses actual sports performance rather than laboratory based experiments and is mainly utilised to inform decision making to those who wish to enhance performance (O'Donoghue, 2010). In the last ten years it has become much more prominent, with a significantly greater number of coaches engaging in the analysis process (Mellalieu, Trewartha and Stokes 2008; O'Donoghue, 2010; Bampouras, Cronin and Miller, 2012). Performance analysis can be split into two broad domains in terms of a research perspective: technical and tactical analysis (Hughes and Bartlett, 2002). Technical analysis refers to the performance of skills, for example the execution of a successful pass in football, whereas tactical analysis is more concerned with using these skills in such a way as to achieve success, for example the decision of where to pass the ball in relation to the opposition (O'Donoghue, 2010). Recent research has mainly been conducted using both technical and tactical analysis, in particular for combat sports such as karate and judo (Andreato *et al*., 2013; Miarka *et al*., 2014; Tornello *et al*., 2014; Tabben *et al*., 2015); however the tactics used by athletes and these effects on performance have also been researched singularly (Jäger and Schöllhorn, 2007).

In terms of practical uses of performance analysis, it has been suggested that there are five key practical applications (Hughes and Franks, 2008): (a) tactical analysis, (b) technical evaluation, (c) analysis of movement, (d) development of a database and modelling and (e) educational use for coaches and athletes. The use of tactical analysis can be used to provide feedback for use within the coaching process (Brackenridge and Alderson, 1985; O'Donoghue and Mayes, 2013), allowing coaches to improve the quality of feedback they give to their athletes (Brown and Hughes, 1995; Murray, Maylor and Hughes, 1998) and adapt training sessions to improve weaker areas (Deutsch, Kearney and Rehrer, 2007). This feedback can be used not only to provide feedback for the athlete, but also for any opponents in order to highlight strengths and weaknesses (Hughes and Franks, 2005). The simplest process of feedback follows the stages of data, process and information, as proposed by Franks, Goodman and Miller (1983). It suggests that the data is collected, analysed and then provided to the coach to give feedback to their athletes, before the process is repeated once again (O'Donoghue and Mayes, 2013). There are examples of tactical analysis being used successfully within tennis (O'Donoghue and Ingram, 2001; Hughes and Bartlett, 2002) to provide feedback to athletes, which is why this research project will use tactical analysis.

For performance analysis to be used effectively in the feedback process, precise operational definitions of key performance indicators should be established before the analysis takes place (Hughes, 2004; O'Donoghue, 2010). This allows the analyst to draw reliable conclusions from the data to give to coaches and athletes (Hayen, Dennis and Finch, 2007). Hughes and Bartlett (2002) discussed the key role of performance indicators in relation to different sport categories, such as invasion games and net and wall games. They supplied numerous performance indicators for different sports, supplying operational definitions from previous studies to allow future research to be reliable. For tennis, it has been suggested that there are three key performance indicators (Hughes and Clarke, 1995): (a) player positioning, (b) ball placement and (c) rally times. Rallies were also identified by Taylor and Hughes (1998) as important to tennis strategy in terms of the number of shots made per rally, but they also acknowledged that winners to errors ratio and the quality of serves and returns are also of great importance. What is clear to see from this previous research is that there are no standard set of performance indicators used for tennis analysis. Therefore this is an area of research which would be a useful area to investigate. This study will use previously identified serving performance indicators and will hopefully help to clarify that they are important aspects of tennis performance.

Tennis Performance

Early research undertaken in tennis aimed to identify the type of spin used by players when hitting the ball and how this could cause possible injury (Bernhang, Dehner and Fogarty, 1974; King and Baker, 1979). The stroke mechanics used to perform an effective serve are difficult to execute successfully due to the small contact area (Reid, Whiteside and Elliott, 2010) and therefore serving has been suggested to be the hardest stroke to learn in tennis (Mcgehee, 1997). Because of the nature of early research not including many factors, one of the major limitations was that it didn't investigate variables such as the shot used or position of the court (Hughes and Franks, 2008). Research into the physiological demands of tennis have also been studied both within young tennis players and the elite (Gomes, Coutts, Viveiros and Aoki, 2011; Torres-Luque, Cabello-Manrique, Hernández-García and Garatachea, 2011), the results showing that rally lengths decrease due to fatigue. Another psychological study identified relationships between social support and key components of performance, one of which was the worry of performing a double fault (Rees, Ingledew and Hardy, 1999). This showed that knowing you would perform less double faults would enable the player to perform to a higher level. This showed that even from a psychological perspective, an effective serve can improve a player's performance.

However the findings from this study showed that this was only the case when the attention was concentrated on these components of performance.

More recent research into tennis has been considerably varied, which has enabled there to be plenty of areas which can be further developed and linked with other aspects of the game. The effects of ball compression on match outcomes has been studies, with significant differences being found for variables such as rally speed and shots played from the net (Kachel, Buszard and Reid, 2015). There was no impact found for serving variables however, in particular the number of double faults and 1st serves which landed in. Choi (2014) discussed the key performance indicators in tennis within Grand Slams, coming to the conclusion that two of the four most important factors relating to winning performances were the winning percentage of successful 1st serves and the winning percentage of successful 2nd serves. Current research has also focussed in abundance on biomechanical constraints (Reid, Whiteside, Gilbin and Elliott, 2013; Reid, Giblin and Whiteside, 2015; Whiteside, Elliott, Lay and Reid, 2015). The ball toss and effects this may have on the tennis serve have also been analysed, with results showing that there is not as much impact as may have been previously thought (Reid, Giblin and Whiteside, 2015). One study analysed the kinematic data for the tennis ball and racket both before and after serving contact and compared the data between 1st and 2nd serves (Ma *et al*., 2013). They concluded players who had higher 1st and 2nd serve percentages were more likely to win, whereas those players who had high numbers of double faults and lost a greater number of points on the return were more likely to lose the match. Hughes and Bartlett (2002) agreed that the serve is an important part of tennis; however they also identified other variables which were indicators of success. They stated that the player who had the greatest number of winners with the least number of errors would be the player to win.

Serving Strategy

In regards to the importance of the serve, a recent study suggested three factors which were statistically significantly different between winners and those players who were defeated (Filipčič, Čakš and Filipčič, 2011). These were: (a) number of double faults, (b) percentage of points won on own serve and (c) total number of points won in the match. This would suggest that winners had a more reliable serve, a higher success rate on their 2nd serve and won more points in the match, as they performed fewer double faults than players who were defeated. Although there was no conclusive evidence on whether the serve is the most important part of a player's game, it did show that having a successful and consistent serve gives the player a distinct advantage against their opposition. The one disadvantage of this study is that the participants were all women and so the results cannot be generalised to men.

One area in particular which has not been investigated to a great extent is the zonal positioning of serves. An early study discussed the differences between the zonal positioning of serves between court surfaces, but didn't take into account gender of the players (Unierzyski and Wieczorek, 2004). Gillet, Leroy, Thouvarecq and Stein (2009) examined serve and serve-return placement strategies on clay court surfaces for men's singles. They identified that servers win significantly more points from topspin serves than from slice serves, with 2nd serves being more likely to be aimed at the players backhand from each side. They concluded that serves and serve-returns highly influence match results for elite male tennis players. O'Donoghue (2015) discussed the proportion of points won serving to different areas of the service court in the 2012 US Open men's singles final between Murray and Djokovic. He found that Murray served more to the left and yet was more successful when serving to the right.

Serving placement between right and left handed players was investigated by O'Donoghue (2009) where he showed that players tend to serve to their players backhand, regardless of whether the player is right or left handed. Loffing, Hagemann and Strauss (2009) also investigated placements of serve and although a significant difference between left handed and right handed players was found, neither studies investigated any differences between genders nor percentage of successful serves. This study used an automated ball tracking system called Hawk-Eye to show ball trajectories, allowing placements of serves within each service box to be identified. This system was first used by the International Tennis Federation (ITF) during the Miami Masters in 2006. It has since been used at all international elite tennis tournaments to allow players to query line-calls made by the umpires. One of its main uses is to identify whether a ball has landed in or out (Kolbinger and Lames, 2013), as an incorrect call by an umpire can win or lose a player a game, set or even a match (Brody, 2004). Hawk-Eye is also useful for providing detailed match analysis and animated shot replays for use on television (Gaughan, 2005; Mather, 2008). The use of this technology, along with software packages such as SIMI Scout software (SIMI Reality Motion Systems GmbH, Munich, Germany) that helps to identify shot placements (Hurnik, Unierzyski and O'Donoghue, 2008), has opened up opportunities for future research into service placements. In spite of this, few studies have examined this in any great detail by using these systems and therefore service placement is an area of research which could be further developed.

Gender Effects in Tennis

O'Donoghue and Ingram (2001) examined the effect gender and court surface on tennis strategy in elite singles tennis. They found that there were more rallies above 7 seconds in ladies singles and that these were more likely to occur on the baseline than in men's singles. The results showed that gender and court surface both have a significant influence in singles tennis. O'Donoghue (2013) has recently discussed the probability of rare events in professional tennis and how often it is that these will occur. He discussed matches such as the 2010 Wimbledon match between John Isner and Nicolas Mahut who played 138 games in their final set as well as other rare occurrences such as winning a perfect set (winning all 24 points). His analysis suggested that a 138 game final set will only occur once every 2381 years in ladies singles and once every 240 years in men's singles. Similarly, the perfect set in men's singles is expected once every 83 years in ladies singles and once every 214 years in men's singles. The results in both of these

studies suggest that men's and ladies singles have vast differences and therefore should not be treated in the same way when it comes to expected results within analysis.

Comparing genders within serving is also a subject topic which has been identified; with studies suggesting there are fewer aces in ladies singles due to a less powerful serve and a greater focus on positioning and anticipation (Hohm, 1987). This is in agreement and has been further developed and linked by more recent research, suggesting ladies only focus on positioning due to having less powerful serves than men Bahamonde (2000). As men and ladies never play against each other except for during mixed doubles, this is not something which is of great importance when performing in a single sex environment. On average, men serve one ace for every eight legal serves which is significantly different to the number of aces that ladies perform (Cross and Pollard, 2009). Men have also been found to win a significantly greater number of points off their serve than the ladies, which suggests that serving is of greater importance in men's singles than in ladies singles (Furlong, 1995; O'Donoghue and Ingram, 2001). On the other hand studies have found that an elite tennis player will serve on average 60% of their first serves in regardless of gender (Barnett, Meyer and Pollard, 2008; Reid, McMurtrie and Crespo, 2010) and therefore gender comparisons with the tennis serve are still to be confirmed.

One study looked solely at the service and how important it was in Grand Slam singles matches (O'Donoghue and Brown, 2008). The aim was to determine whether a player gains serving advantages from having the most aces or serve winners, or whether the advantage still continued after rallies of 3 shots or more. They found that for men's and ladies singles, the serving player won less than 50% of points in rallies that lasted longer than 4 shots. This showed that the server only seems to have an advantage in the first 4 shots of the rally. There were also gender differences in regard to serving advantage, as in ladies singles once the rally reached 3 shots the player lost the advantage of the serve. Ladies were also found to serve a greater number of double faults than men. Men were found to have a greater advantage than ladies when it came to second serve points as they have a greater number of unreturned second serves.

Previous research has clearly shown that court surfaces influence the importance of the serve (Hughes and Clark, 1995; O'Donoghue, 2001). In particular, serves seem to be of greatest importance on grass courts at Wimbledon (O'Donoghue and Brown, 2008). Gender is also an important factor that influence serves, with research suggesting that serves have more significance to men than ladies (Furlong, 1995). There is however very little research which studies whether there are optimum service positions for 1st and 2nd serves and if this differs between genders. This research study will therefore aim to fill this gap in the literature and hopes to provide evidence to prove or disprove the hypotheses previously made.

CHAPTER 3

METHODS

Research Design

Web statistics relating to the serve were taken from the Wimbledon 2014 website for a total of 248 singles matches. A validation study was performed by analysing 4 men's and 4 ladies singles matches and conducting a Chi square goodness of fit test. This determined that the statistics for the placement of serves from the Wimbledon website were valid ($p > 0.8$) and therefore the main study could take place. This involved gathering web statistics on the serve and inputting these into Excel. Once correctly formatted, the spread sheets were converted to SPSS to calculate mean percentages and difference testing between variables using a Mann-Whitney U test.

Validation Study

A validation study was undertaken on 4 ladies and 4 men's singles matches to ensure that the data being taken from the Wimbledon website was accurate and also was similar to what the researcher found. Validation is the measure of the extent to which something measures what it is supposed to measure (Berg and Latin, 2008) and therefore this validation study would ensure that any significant or non-significant results obtained could be used at face value rather than being taken doubtfully (O'Donoghue, 2012). The 8 matches which were used in this validation study are identified in Table 1. The researcher observed the number of points that landed in each zone as well as how many points were then won in these zones; this was done for both 1st and 2nd serves for each player. No general serving data was collected, for example the numbers of aces and double faults, as collecting and verifying the zonal data was deemed a large enough sample by the researcher in order to verify all of the data used online. The majority of the match footage utilised by the researcher was recorded on BBC1 or BBC2 during Wimbledon 2014, whilst some was taken from various internet sites. The results for each match was input into separate excel spread sheets and then compared to the results obtained from the Wimbledon website in order to ensure the validity of the results used in this study. To do this, a Chi squared goodness of fit test was carried out on SPSS to compare the similarities of the results. Chi squared tests compare the frequency of data that is expected compared to the frequency of data that is observed, to identify whether data is independent or not (Berg and Latin, 2008). This test was used to compare the distribution of the data, to one degree of freedom, observed by the researcher to the expected data which was collected from the Wimbledon 2014 website (O'Donoghue, 2010; O'Donoghue, 2012). The outcome showed that all of the variables tested had a similarity of 0.8 or above (see Appendix A) and therefore were satisfactory enough for the main study to take place.

Table 1. Matches used in the validation study.

Gender	Match	Player 1	Player 2
Men	Quarter Final	A Murray	G Dimitrov
	Semi Final	N Djokovic	G Dimitrov
	Semi Final	R Federer	M Raonic
	Final	N Djokovic	R Federer
Women	First Round	D Hantuchova	E Bouchard
	Third Round	S Williams	A Cornet
	Quarter Final	E Bouchard	A Kerber
	Final	E Bouchard	P Kvitova

Performances

The participants used in the main study were all of the female and male tennis players who played one or more singles matches in the main draw at Wimbledon 2014, a full list of which can be found in Appendix B. All the participants of this study were analysed in at least one singles match from Wimbledon 2014 as research has shown that the placement of serves are statistically more important on grass than on any other surface (O'Donoghue, 2001). Matches were selected on the basis of satisfying the following criteria: the full match was completed and all of the serving data required was available online. Any match that was discontinued due to a player retiring due to injury or illness was not included, as in these cases sets were not completed and therefore fewer statistics were available for the serve and therefore could affect the results. If any serving data that was required for this study was not available online, then the match was not used as the full match statistics would not be able to be calculated and therefore would impact on the results. This meant that from the total of 256 matches that were played during singles matches at Wimbledon 2014, a total of 248 matches were analysed: 126 men’s and 122 ladies matches.

Variables

The data collected from the Wimbledon 2014 website related to general serve statistics, for example the number of double faults or aces made in the match by each player, as well as the zonal positioning of serves in the service boxes, for example the number of serves that landed out wide or at the body. In order to investigate the zonal positioning of serves in this study, the service box was split vertically into three equal zones which have been utilised effectively by previous researchers to clarify shot placement issues (Loffing, Hagemann and Strauss, 2009). These zones allowed three different placements of serves to be identified within each service box (Matsuzaki, 2004): out wide, at the body and down the T. For the purpose of this study, the zones were labelled Zone 1 for out wide serves, Zone 2 for at the body serves and Zone 3 for down the T serves (see Figure 1). The data for the positioning of each 1st or 2nd serve from both the deuce and advantage side were combined, as the point being played was not of relevance for this study. Data in relation to zonal positioning and number of serves that land in were collected for both 1st and 2nd serves. Definitions for these zonal positions, along with other action variables used in this study, are defined in Appendix C.

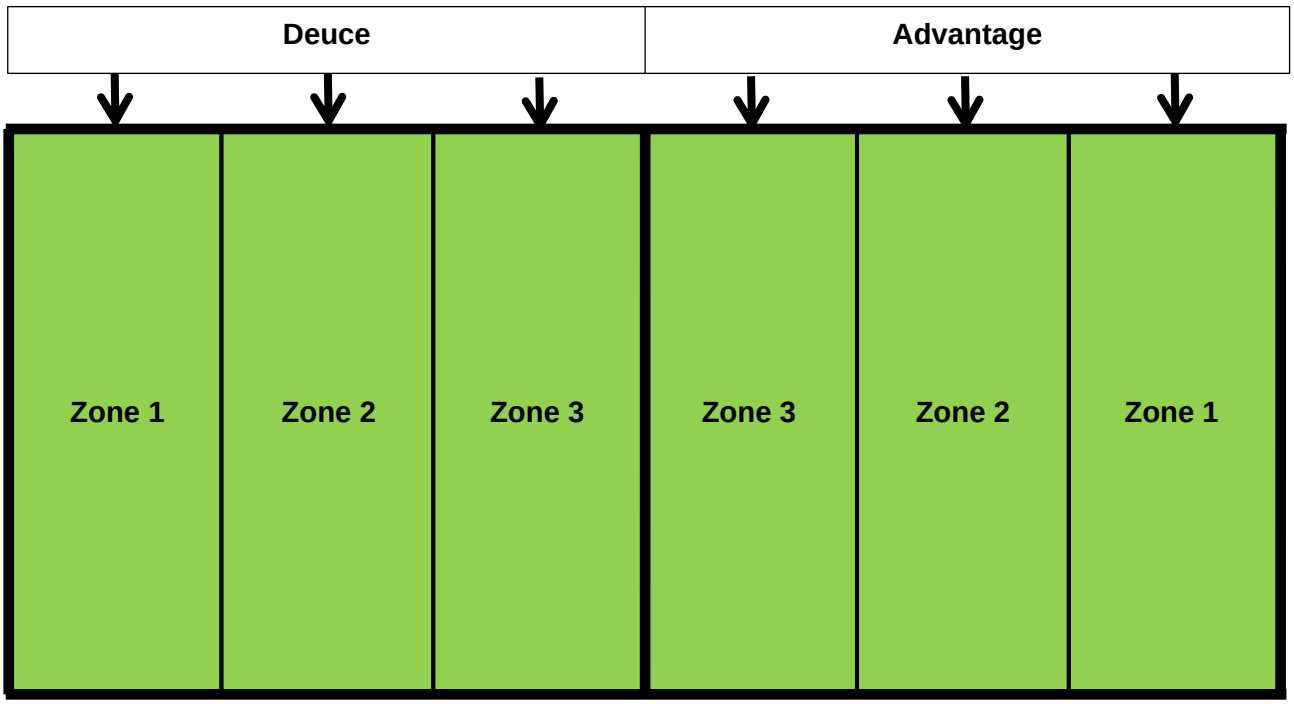

Figure 1. A representation of the deuce and advantage service boxes with their corresponding zone numbers.

Procedure

Using the Wimbledon 2014 website, serving data was gathered for both men's and ladies singles matches. The data was collected after the event had taken place, allowing the researcher to obtain detailed analytical information on both players for each match played. The summary and serve statistics collected were input into spread sheets on Microsoft Excel; one for men and one for ladies. These spread sheets contain all of the serving data for each player in every match that they played, running in order from the 1st round all the way through to the final. Players' names were then removed in order to protect anonymity (Berg and Latin, 2008) and data was combined for zonal positions of serves taken from the deuce and advantage sides, halving the number of variable columns needed for 1st and 2nd serves (see Appendix D). The data was also reorganised to ensure an easy and effective transfer to SPSS; an example of the final data sheets used and the information gathered can be found in Appendix E.

Data Analysis

Once all the data was collected for the main study and input into Excel spread sheets, the data was converted to an SPSS spread sheet where means and standard deviations for each performance indicator were calculated to allow comparisons between 1st and 2nd serve and also between genders (see Appendix F). Means were used to calculate the average distribution of the population, whilst standard deviations calculate the variance or spread of the data around the mean (Berg and Latin, 2008). The number of aces and double faults were left as numbers for comparisons between genders, whereas the rest of the serving data was converted to percentages in order to contrast the data e.g. the percentage of 1st serves that landed in compared to the number of points won off the 1st serve. For the zonal analysis of the serves, percentages were also calculated to determine how many points were won compared to how many serves landed in that zone.

For this study, there were two independent samples which needed to be analysed in order for comparisons to be made (O'Donoghue, 2010): (a) men's and ladies and (b) 1st and 2nd serves. This indicated that either a parametric independent T-test or a non-parametric Mann-Whitney U test would need to be used (O'Donoghue, 2010). A parametric test is used on data that which is thought to be normally distributed, whereas non-parametric tests are used when data is not thought to be normally distributed (Berg and Latin, 2008). When analysing this data there were no prior assumptions about possible distributions of the dependent variables and therefore the non-parametric Mann-Whitney U test would need to be used (O'Donoghue, 2012). The Mann-Whitney U test allowed the researcher to compare the serving data between genders and 1st to 2nd serves in order to determine whether there was a significant difference between these data sets (Berg and Latin, 2008).

CHAPTER 4

RESULTS

Table 2 shows a comparison of general serving statistics between men and ladies. In terms of means, the greatest difference is found for the number of aces made per game, with men serving on average just over 9 more aces per match than ladies. The number of aces made per game, as well as the win / in % for 1st serves and the win / all % for 2nd serves was found to be highly significant ($p < 0.001$) in terms of men being higher than ladies. The number of double faults made per game by men was also significantly higher ($p < 0.05$) when compared to the ladies. The only variable for which no significant difference was found between genders related to the percentage of 1st serves that landed in compared to all 1st serves that were attempted ($p > 0.05$).

Table 2. A comparison of general serving statistics between genders (mean ±SD).

	Men	**Ladies**
Aces	12.87 ± 8.48 [a]***	3.59 ± 3.47
Double faults	3.52 ± 2.85 [a]*	2.91 ± 2.39
1st Serves In / All %	64.80 ± 6.16	64.18 ± 8.27
1st Serves Win / In %	74.70 ± 9.02 [a]***	65.72 ± 11.13
2nd Serves Win / All %	53.18 ± 10.57 [a]***	46.70 ± 11.72

Mann-Whitney U tests revealed significant differences between genders within the variables: * ($p < 0.05$), ** ($p < 0.01$), *** ($p < 0.001$). The significant difference was found to be in favour of men [a] or ladies [b].

Table 3 shows comparison results of the placement of serves between men and ladies. It identifies the mean percentage of points won compared to all those attempted between genders for Zones 1 to 3. The highest win / all % of 67.85% for men was found in Zone 1 whilst their lowest win / all % of 54.10% was found in Zone 2. This zonal positioning was similar for the ladies, whose highest win / all % of 57.95% was also found in Zone 1 and lowest win / all % of 46.66% similarly found in Zone 2. For Zones 1 and 3, the win / all % were found to be highly significant ($p < 0.001$) in terms of men having a higher mean than ladies. The win / all % was not significant ($p > 0.05$) for Zone 2 however, suggesting the results for men's and ladies are similar.

Table 3. A comparison of points won for different zones between genders (mean ±SD).

	Men	Ladies
Zone 1 Win / All %	67.85 ± 42.25 [a]***	57.95 ± 41.48
Zone 2 Win / All %	54.10 ± 34.26	46.66 ± 36.63
Zone 3 Win / All %	65.67 ± 26.22 [a]***	55.15 ± 43.06

Mann-Whitney U tests revealed significant differences between genders within the variables: * ($p < 0.05$), ** ($p < 0.01$), *** ($p < 0.001$). The significant difference was found to be in favour of men [a] or ladies [b].

Table 4 shows comparison results for the placement of serves between 1st and 2nd serves. It identifies the mean percentage of points won compared to all those attempted between 1st and 2nd serves for Zones 1 to 3. For the 1st serve, the highest win / all % of 72.58% can be found in Zone 1 whilst the lowest win / all % of 50.45% from serves in Zone 2. Although the highest win / all % of 53.38% for 2nd serves is also located in Zone 1, the lowest win / all % of 50.08% can this time be found in Zone 3 and not Zone 2 as for 1st serves. For Zones 1 and 3, the win / all % were found to be highly significant ($p < 0.001$) in terms of the 1st serves having a higher mean than the 2nd serves. Just as for the gender comparisons shown in Table 2, the win / all % was not significant ($p > 0.05$) for Zone 2 suggesting that the results for 1st and 2nd serves were similar.

Table 4. A comparison of points won for different zones between 1st and 2nd serves (mean ±SD).

	1st Serve	**2nd Serve**
Zone 1 Win / All %	72.58 ± 39.32 [a]***	53.38 ± 42.73
Zone 2 Win / All %	50.45 ± 39.26	50.43 ± 31.60
Zone 3 Win / All %	70.93 ± 18.25 [a]***	50.08 ± 45.01

Mann-Whitney U tests revealed significant differences between 1st and 2nd serves within the variables: * ($p < 0.05$), ** ($p < 0.01$), *** ($p < 0.001$). The significant difference was found to be in favour of 1st serve [a] or 2nd serve [b].

Figure 2 shows schematic images of the zones used in the service boxes for 1st and 2nd serves. Gender comparisons as well as differences between 1st and 2nd serves can be identified through the use of a percentage bar chart. It shows that for each zone, men had a higher mean percentage of serves won against those that landed in compared to ladies. The highest win / in % for men was 78% compared to 67% for the ladies. The differences in the lowest win / in % were 54% for men and 44% for ladies. These results also show that both men and ladies are revealed to have a higher win / in % for 1st serves than for 2nd serves for Zones 1 and 3. The low results shown in Zone 2 are identical through genders for both 1st and 2nd serves. Zone 2 shows the lowest values for win / in % for men's 1st serves, men's 2nd serves and ladies 1st serves however was not the lowest value for ladies 2nd serves.

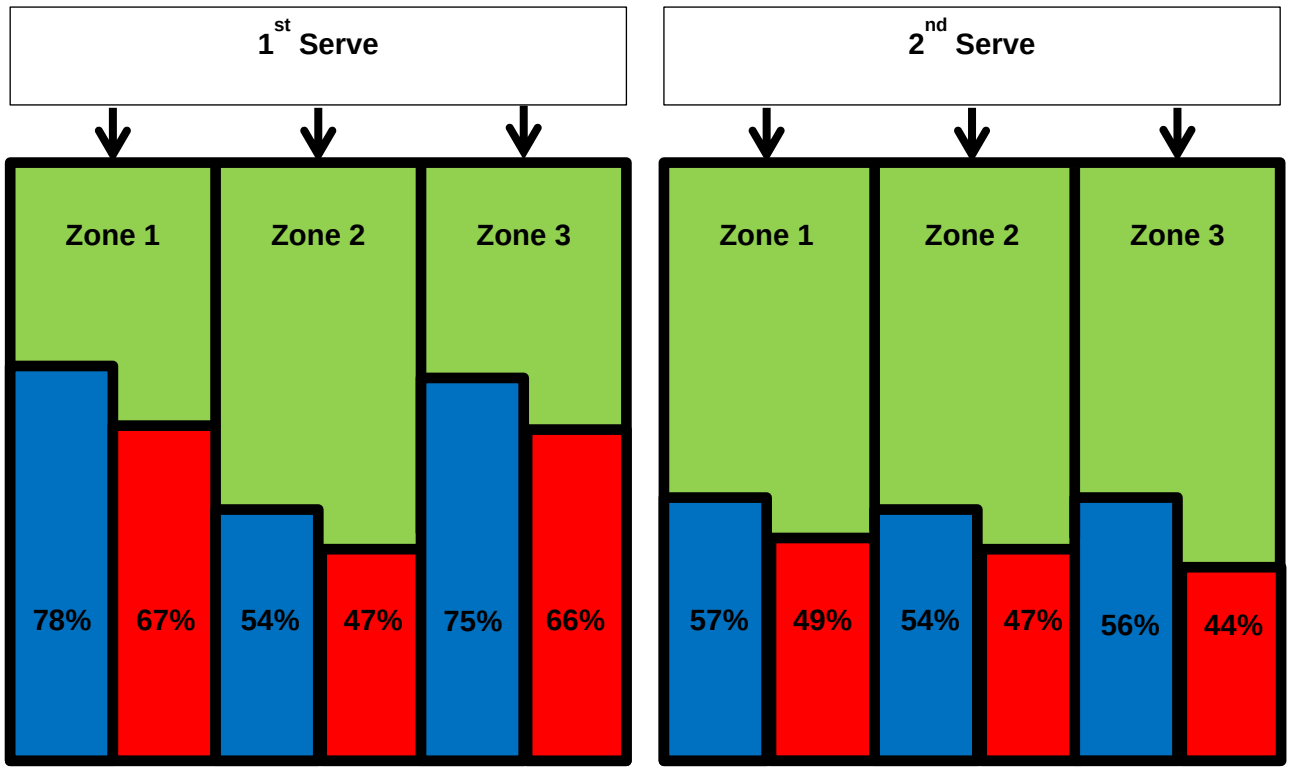

Figure 2. An image of two service boxes showing the percentage of serves won compared to those that landed in for men (blue) and ladies (red) in each zone for 1st and 2nd serves.

CHAPTER 5

DISCUSSION

Gender Differences

In previous research men have been found to perform significantly more aces than ladies (Hohm, 1987; Magnus and Klaassen, 1999; Brown and O'Donoghue, 2008; Cross and Pollard, 2009) which would support the significantly greater number of aces performed by men in this study ($p < 0.001$). It is likely that these differences are due to the strength and height differences between genders, as males are much stronger and taller than females and so can hit the ball at greater speeds with more ease (Verlinden *et al*., 2004). The significantly higher number of double faults ($p < 0.05$) performed by ladies in this study also supports previous research in this area (O'Donoghue and Brown, 2008). Performing a higher number of aces and a lower number of double faults are suggested to be key performance indicators for successful players (Patterson, 1964; Filipčič, Filipčič and Berendijaš, 2008; O'Donoghue and Brown, 2008; Ma *et al*., 2013). The higher number of double faults performed by the ladies is likely to be highly detrimental to performance, as shown in a previous study into female serving strategies (Filipčič, Čakš and Filipčič, 2011). The large variance in the ladies number of double faults in each match should be noted, as it could be that a few matches with very high numbers of double faults have brought the mean higher than expected. Due to the large sample size used in this study however, it is unlikely that this is the case as a select few outliers are unlikely to change the results that drastically (Hughes and Franks, 2008). This result has some practical implications for coaches of players who take part in ladies singles. The coach should design drills to work on serving accuracy in order to reduce the number of double faults made by their player, thus increasing one of the key performance indicators for successful performance.

Both genders served over 60% of their 1st serves in, which has been shown to be the favourable percentage for an average player (Pollard and Pollard, 2007; Barnett, Meyer and Pollard, 2008; Reid, McMurtrie and Crespo, 2010). The men were shown however to win more points off both their 1st and 2nd serves than the ladies. This would suggest that the serve is of greater importance in men's singles than for ladies singles in terms of points won (Furlong, 1995; O'Donoghue and Ingram, 2001; Gillet, Leroy, Thouvarecq and Stein, 2009). This supports the hypothesis suggested at the start of this study that men would win significantly more points than the ladies. One possible reason for this is because men serve 1st serves at a greater speed than ladies (McMahon and de Mestre, 2002). As these serves are faster, they will be more difficult to return and therefore likely to cause the returner to do a forced error (Hohm, 1987; Furlong, 1995; Bahmonde, 2000; Vaverka and Cernosek, 2013). For 2nd serves, the results from this study show that men win

significantly more points ($p < 0.001$) than ladies. Previous research has suggested that this is due to men serving a larger number of unreturned 2nd serves (McMahon and de Mestre, 2002; O'Donoghue and Brown, 2008). Both studies suggested that men were able to place 2nd serves with higher accuracy than ladies and therefore have a greater chance of winning the point. This supports the hypothesis made at the start of this study that men would win more points off their serve than the ladies.

The differences between the percentages of points won compared to points that landed in (win / in %) for men and ladies was 9%, similar to the difference of 10% for the lowest win / in %. This shows that although there is clearly a difference between the genders, it seems to be the same difference for both 1st and 2nd serves. This suggests that both men and ladies make the same changes to their 1st and 2nd serves. They hit a more powerful 1st serve, which will win them a greater number of points, whilst focusing on accuracy for the 2nd serve, which are easier serves to return (Trabert and Hook, 1984; Douglas, 1992; Groppel, 1992; Bahmonde, 2000; Chow *et al*., 2003; Girard, Eicher, Micallef and Millet, 2010). Men are said to win between 70-75% of their 1st serves, which would agree with the findings in this study that showed men winning 73% of their 1st serves (Pollard, 2008; Reid, McMurtrie and Crespo, 2010). It has also been suggested that men will win a greater number of 1st serves than women, but are less likely to serve 1st serves into the service box (Furlong, 1995; O'Donoghue and Ingram, 2001; O'Donoghue and Ballantyne, 2003). Although this cannot be inferred from the current study, it is reasonable to suggest that this is a possible explanation for why men have a higher win / in % than the ladies. Men winning a higher percentage of points off the serve but serving in a lower percentage of points would indicate a higher overall win / in %. The ladies overall win / in % will therefore be lower due to their lower win percentage but higher in percentage.

This study found key significant differences between genders in terms of the zonal positioning for the 1st and 2nd serve. This supports previous research conducted which suggested men's and ladies singles should not be treated in the same way as they have a wide variety of variances (O'Donoghue and Ingram, 2001; O'Donoghue, 2013; Hizan, Whipp, Reid and Wheat, 2014). The highly significant ($p < 0.001$) differences found in favour of men for both Zones 1 and 3 would suggest that men are able to place the ball in these zones in a much more difficult position for their opponent to return. This agrees with suggestions made by Bahmonde (2000), although it disputes previous research conducted by Hohm (1987) who stated that ladies were able to place serves in a more favourable position than men. It should be noted that the positions that the service ball lands within each Zone could include closer to either the inside tram line on the edge of Zone 1 or the centre line at the edge of Zone 3. Therefore future research should study the exact position for each serve performed in order to determine conclusive evidence for which gender is able to place serves more favourably in the service box.

1st and 2nd serves

Analysis of the zonal positioning of 1st and 2nd service balls identified significant differences. Zones 1 and 3 were shown to be highly significant differences in terms of 1st serves having a greater win / in % than for 2nd serves ($p < 0.001$). This suggests that for these zones, more serves are won off the 1st serve than the 2nd serve. A reason for this could be that the 1st serve is focused more on speed and therefore the returner will be less likely to be in a good position in order to return the serve successfully. Therefore more points are won from serves which the returner is unable to return or which put them under pressure and cause them to lose the point (Chow *et al*., 2003; Gillet, Leroy, Thouvarecq, and Stein, 2009; Hizan, Whipp, Reid and Wheat, 2014). With the 2nd serve more focused on accuracy, it is likely more serves will land in but will be easier to return and therefore less points will be won by the server (Girard, Eicher, Micallef and Millet, 2010). This result suggests a serve positioning difference between 1st and 2nd serves, unlike previous research which had only identified differences between left and right handed players serve (Unierzyski and Wieczorek, 2004; Loffing, Hagemann and Strauss, 2009; O'Donoghue, 2009) and also between the elite and children who are non-elite (Schmidhofer, Leser and Ebert, 2014). Coaches could use this information in order to focus their players' on having a more powerful yet still accurate 2nd serve. Their opponent will not be expecting the 2nd serve to be powerful and will therefore be less prepared and more unlikely to return the ball successfully.

The results from Figure 2 show that 1st serves have a higher win / in % than for 2nd serves. This supports the hypothesis made at the start of this study which suggested that points were more likely to be won off the 1st serve than the 2nd serve. It has been suggested in previous research that more points will be won from 1st serves than from 2nd serves, although more 2nd serves will land in than for 1st serves (Furlong, 1995; O'Donoghue and Ingram, 2001; O'Donoghue and Ballantyne, 2003). 2nd serves are hit on average 30 km / hr slower than 1st serves (Bahamonde, 2000; O'Donoghue and Ballantyne, 2003), utilising a greater amount of both sidespin and topspin in order to try and place the ball more accurately in the court (Trabert and Hook, 1984; Douglas, 1992; Groppel, 1992). This accuracy means that 2nd serves are more likely to land in the service box than 1st serves (Chow *et al*., 2003; Girard, Eicher, Micallef and Millet, 2010) but are also easier to return due to their slower speed (Crespo and Miley, 1998). Coaches should therefore try and increase the speed of their player's 2nd serve whilst still keeping the accuracy, as this would improve the number of points won off the 2nd serve.

In terms of the percentage of points won compared to those that landed in, the highest result for 1st serves is 21% higher compared to the highest win / in % for 2nd serves, with their lowest win / in % being only 3% apart. This would suggest that although there is a large difference between 1st and 2nd serves in terms of the highest win / in %, there seems to be very little difference in terms of their lowest percentage. It is interesting to note that the highest win / in % found for both the 1st and 2nd serves is in Zone 1, with the lowest win / in % for both being found in Zone 2. This contradicts previous research which suggested that the greatest win / in % is found in Zone 3 but agrees with the results shown for Zone 2 (O'Donoghue, 2015). This shows a similarity rather than a difference between the 1st and 2nd serve, which is possibly due to serves being easier to return from Zone 2 and less easy to return from Zone 1. Zone 2 serves are aimed at the body, which is the easiest zone for which an opponent can return successfully as they have less distance to move in order to be in the correct position to execute a successful shot. Serving a ball into Zones 1 and 3 would require the returner to move a greater distance and therefore they would be more likely to make an error.

Combined Variables

When looking at the analysis for all four variables (men, ladies, 1st serves and 2nd serves), Zone 2 was found to be the least successful zone in terms of points won compared to those that landed in. Serves that land in this zone land in the middle third of the service box and after the bounce are aimed at the returner's body (Matsuzaki, 2004). As the ball is so close to the returner, they have more time to react and are therefore more likely to be able to return the ball successfully which is disadvantageous to the server (Furlong, 1995; Unierzyski and Wieczorek, 2004; O'Donoghue and Ballantyne, 2004; O'Donoghue and Brown, 2009). This would indicate that the returner could win more points when the ball lands in Zone 2, lowering the servers win / in %. This has practical implications for coaches in terms of planning possible drills for their players to complete in training. They could set up accuracy drills which will help the athlete to serve more balls into Zones 1 and 3 compared to Zone 2. They might also use positive reinforcement, whereby the player can only play the point out if they serve the ball into Zones 1 and 3; if the ball lands in Zone 2 they automatically lose the point.

In terms of the placement of serves, one result directly contradicted current research conducted by O'Donoghue (2015). Their results from an analysis of serving positioning during the 2012 US Open Men's singles final showed that the player who won the match was more successful when serving to the right (Zone 3). Earlier studies also found that players are more likely to serve to their opponent's backhand (Gillet, Leroy, Thouvarecq and Stein, 2009; O'Donoghue, 2009), which for all right handed players would mean serving the ball into Zone 1. However, in terms of comparisons between genders and between 1st and 2nd serves, this study suggests that players are more successful and win more points off their serve when serving to the left (Zone 1). There are many explanations that may account for the differences in results found between these studies. One such reason is that O'Donoghue (2015) only analysed one match compared to this study which analysed 248 matches, which would allow this study to generalise results with greater reliability. Another reason could be these three studies were not focusing on obtaining the exact same outcomes from their results. The first was focused on the type of spin used on the serve (Gillet, Leroy, Thouvarecq and Stein, 2009), whilst O'Donoghue (2009) observed differences between right and left handed players and O'Donoghue (2015) collected results for successful and unsuccessful players, this study observed differences between genders and between 1st and 2nd serves. In order to establish whether these pieces of

research do indeed contradict, future researchers should study the relationship between these variables and compare more than one set of variables at a time.

Limitations and Future Research

For most of the variables analysed in this study, significant differences were found in terms of males having significantly more performance indicators that would suggest a successful performance than ladies. Nevertheless there were two variables for which there were no significant differences found between genders, one of which was the win / in % for serves landing in Zone 2. It is worth noting that there were no significant differences for win / all % of serves for Zone 2 between genders or between 1st and 2nd serves. From the results this would suggest that this is due to the lack of serves performed in this zone rather than because of a great lack of points won. Serves are less likely to be aimed at this zone as it is aimed at the opponent's body and therefore they are more likely to successfully return the ball and not be on the defence (O'Donoghue and Brown, 2009; Unierzyski and Wieczorek, 2004). The non-significant results could be due to less serves landing in this area that for Zones 1 and 3, and not enough data was gathered in order to determine a significant difference (Hughes and Franks, 2008). A great strength of this study is that it has a very large sample size; analysing 248 singles matches which would contain at least 14,928 serves if the winner of each match won every point. It is therefore unlikely that this study does not have enough serving data in order to provide conclusive evidence. However as Zone 2 had the least amount of data, future studies should look at multiple Grand Slams in order to increase the data gathered for Zone 2 and thus be able to make a reasonable assumption on this.

In terms of the other non-significant variable found in this study, it was found that men and ladies had no significant difference between their values for in / all % of 1st serves. Previous research has suggested that both men and ladies will serve on average 60% of their 1st serves into the service box (Barnett, Meyer and Pollard, 2008; Reid, McMurtrie and Crespo, 2010), agreeing with this study's results of around 64% for both genders. This shows that in some aspects of the serve, there are very little or no gender differences to be found. A key strength of this study was that it examined previous research into serving on different court surfaces, finding that serves are of more importance on grass surfaces than clay courts (Furlong, 1995). Serves have been shown to be less important at the Australian Open than at Wimbledon, due to a greater number of aces and points won off the serve on grass than on hard courts (Hughes and Clark, 1995; O'Donoghue, 2001).

This study therefore examined serves on their most important surface in order to establish the most important statistical differences between genders and 1st to 2nd serves. Although these pieces of research identified have indicated that serves are of more importance on grass than on any other surface, other studies have shown the serving player will win a greater number of points than returner not just at Wimbledon but at all 4 Grand Slam tournaments (O'Donoghue and Ingram, 2001). The previously mentioned study, which identified serves as being more important on grass than on clay (Furlong, 1995), only examined serves during tie breaks and therefore their data cannot be generalised to all serving points within a match. The data from this study was only collected from singles matches at Wimbledon and therefore these results can only be generalised to grass court matches. It would therefore be useful for future research to take into account all four court surfaces, perhaps comparing serving placements at all four grand slams.

One of the key limitations of this study related to the operator reliability when marking the positions of serves within the validation study. This was a difficult indicator to control as the placements were based on the researcher's judgement and so could be influenced by human error (O'Donoghue, 2007; O'Donoghue, 2008). This is a concern as it is possible that other researchers would mark the serve as landing in a different zone to what was found in this study (Hughes and Bartlett, 2002). This is especially an issue on the lines dividing the zones as these are not marked on a tennis court and therefore it is very subjective. In order to improve this, the researcher would need access to a ball tracking system such as Hawkeye. This would allow them to see exactly where the ball lands in each Zone rather than using their own judgement on where they believe the ball has landed. Alternatively, the use of SIMI Scout software could be used as this would allow the bounce of the service to be located (Hurnik, Unierzyski and O'Donoghue, 2008). Using a computerised notation system, such as Dartfish or Studiocode, would be a useful way to do this as it could be linked to the Hawkeye system in order to get accurate live footage of where the ball lands (Hughes and Bartlett, 2002; Gaughan, 2005; O'Donoghue, 2008). This has been used successfully in a previous study by Loffing, Hagemann and Strauss (2009) in order to determine serving placements between right and left handed players and therefore future research could use a similar method in order to compare genders or 1st and 2nd serves. Although the use of the Hawkeye system or other electronic tracking systems is ideal and has been used previously by analysts (O'Donoghue, 2006; Carling, Williams and Reilly, 2009; McGarry, 2009), they are not readily accessible to most athletes and their teams. Even though they can save time, improve accuracy of results and have

become less expensive (Hughes and Franks, 2004), they can still be too expensive for most athletes to be able to afford (Jenkins, Morgan and O'Donoghue, 2007). In terms of practical implications, the analyst will still be able to provide adequate feedback without using Hawkeye, in order for the coach to produce or adapt training sessions.

In terms of research into the placement of serves, this study fills an obvious gap in the literature in relation to comparing genders and the differences between 1st and 2nd serves. Previous research has examined placements differences between successful and unsuccessful players (O'Donoghue, 2015), court surfaces (Unierzyski and Wieczorek, 2004), type of spin used (Gillet, Leroy, Thouvarecq and Stein, 2009) and also comparisons between left and right handed players (Loffing, Hagemann and Strauss, 2009; O'Donoghue, 2009). One variable which has not been examined in terms of service positioning is the side from which the player is serving. Serving positions from the right or from the left on normal points would likely have no effect, however on advantage points it is possible that this would change. Servers might be more cautious when losing on the advantage side or take more of a chance when ahead, which could cause a change in the zonal positions of their serves. As there is very little research identifying differences in serving on the deuce and advantage sides, future research should aim to rectify this by examining zonal placements during these points. It could also be possible for future research to examine the relationships between multiple variables, for example if successful females prefer to serve into different zones than unsuccessful females or compare differences between right and left handed players on different court surfaces. This would help to show interactions between these variables and would be interesting to see if when combined the service positioning is different to when singular.

CHAPTER 6

CONCLUSIONS

This study aimed to identify which zones are more successful in terms of service placement through comparing service placements of genders and for 1st and 2nd serves. The hypothesis suggested that men would win more points off their serve than ladies and also that players will win more points off their 1st serve than their 2nd serve. The results found support the hypothesis both in terms of genders and for 1st and 2nd serves. Men were found to win a higher percentage of points from both their 1st and 2nd serves when compared to the ladies and also won significantly more points for Zones 1 and 3 ($p < 0.001$). This supports previous research stating that in men's singles more points are won off the serve than in ladies singles (O'Donoghue and Ingram, 2001) and is likely due to the greater power that men hit their serves with which makes it more difficult for their opponent to return (Hohm, 1987; O'Donoghue and Brown, 2008; Vaverka and Cernosek, 2013).

The second part of the hypothesis suggested that more serves will be won from Zones 1 and 3 than from Zone 2. Zone 2 was found to be the least successful in terms of win / in % for all four variables, which supports this hypothesis. It has been suggested by previous research that serves landing in Zone 2, which bounce towards the returners body, are more likely to be returned successfully as the returner does not have to move far to return the ball and they therefore have more time to read the ball and make the decision on where to hit their return to (O'Donoghue and Brown, 2009; Unierzyski and Wieczorek, 2004). In terms of practical implications, this information would allow coaches to plan sessions which focus on their players hitting less serves into Zone 2 as this will allow them to have a greater win / in % for both their 1st and 2nd serves.

Overall analysis revealed Zone 1 was the most successful area for service placements for all variables (men, ladies, 1st serves and 2nd serves) in terms of win / in % when compared to Zones 2 and 3. This result is in contrast to recent research by O'Donoghue (2015) who suggested that Zone 3 was more preferable; however this could be due to a much larger sample size used in their study in addition to the differing outcomes of the studies. In order to establish conclusive evidence on the most desired Zone to hit the serve, future research should take into account variables used by both studies; comparing the placements of serves between successful and unsuccessful players, as well as between genders and for 1st and 2nd serves.

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Appendices

APPENDIX A

RESULTS OF THE CHI SQUARED GOODNESS OF FIT TEST ON THE ZONAL POSITIONING OF WEBSITE DATA COMPARED TO THE RESEARCHER'S GATHERED DATA

	Chi Square Result
1st Serve Zone 1 Win	0.997 **
1st Serve Zone 1 All	0.997 **
1st Serve Zone 2 Win	0.901 **
1st Serve Zone 2 All	0.989 **
1st Serve Zone 3 Win	0.957 **
1st Serve Zone 3 All	0.999 **
2nd Serve Zone 1 Win	0.805 *
2nd Serve Zone 1 All	0.977 **
2nd Serve Zone 2 Win	0.844 *
2nd Serve Zone 2 All	0.996 **
2nd Serve Zone 3 Win	0.996 **
2nd Serve Zone 3 All	0.989 **

Chi squared goodness of fit test revealed significant similarities between website data and the researchers gathered data within the variables: * ($p > 0.8$; similar), ** ($p > 0.9$; very similar).

APPENDIX B

A FULL LIST OF THE MAIN SINGLES DRAW FOR MEN'S AND LADIES AT WIMBLEDON 2014.

Mens											
1R	N Djokovic	1R	F Volandri	1R	P Riba	2R	N Djokovic	2R	A Mannarino	3R	J Janowicz
	A Golubev		E Roger-Vasselin		A Mannarino		R Stepanek		T Robredo		T Robredo
1R	R Stepanek	1R	T Gabashvili	1R	L Lacko	2R	G Simon	2R	M Granollers	3R	S Giraldo
	P Cuevas		T Puetz		T Robredo		R Haase		S Giraldo		R Federer
1R	K Kravchuk	1R	A Zuznetsov	1R	M Granollers	2R	M Youzhny	2R	G Muller	3R	M Raonic
	G Simon		F Fognini		N Mahut		J Wang		R Federer		L Kubot
1R	R Haase	1R	G Dimitrov	1R	D Gimeno-Traver	2R	S Querrey	2R	M Raonic	3R	S Bolelli
	V Pospisil		R Harrison		S Giraldo		J-W Tsonga		J Sock		K Nishikori
1R	M Youzhny	1R	L Saville	1R	G Muller	2R	E Gulbis	2R	L Kubot	3R	N Kyrgios
	J Ward		D Thiem		J Benneteau		S Stakhovsky		D Lajovic		J Vesely
1R	J Wang	1R	D Young	1R	P Lorenzi	2R	J Chardy	2R	P Kohlschreiber	3R	M Kukushkin
	A Gonzalez		B Becker		R Federer		M Matosevic		S Bolelli		R Nadal
1R	B Klahn	1R	S Groth	1R	M Raonic	2R	M Cilic	2R	D Kudla	4R	N Djokovic
	S Querrey		A Dolgopolov		M Ebden		A Haider-Maurer		K Nishikori		J-W Tsonga
1R	J Melzer	1R	A Seppi	1R	P Herbert	2R	B Tonic	2R	R Gasquet	4R	J Chardy
	J-W Tsonga		L Mayer		J Sock		T Berdych		N Kyrgios		M Cilic
1R	E Gulbis	1R	D Brown	1R	L Kubot	2R	A Murray	2R	J Vesely	4R	A Murray
	J Zopp		M Baghdatis		J Struff		B Rola		G Monfils		K Anderson
1R	S Stakhovsky	1R	A Kuznetsov	1R	D Lajovic	2R	J Hernych	2R	F Dancevic	4R	G Dimitrov
	C Berlocq		D Evans		G Garcia-Lopez		R Bautista Agut		M Kukushkin		L Mayer
1R	J Shardy	1R	P Carreno Busta	1R	P Kohlschreiber	2R	K Anderson	2R	L Rosol	4R	S Wawrinka
	D Cox		D Ferrer		I Sijsling		E Roger-Vasselin		R Nadal		F Lopez
1R	M Matosevic	1R	S Wawrinka	1R	T Ito	2R	T Puetz	3R	N Djokovic	4R	T Robredo
	F Verdasco		J Sousa		S Bolelli		F Fognini		G Simon		R Federer

1R	M Cilic	1R	Y-H Lu	1R	M Ilhan	2R	G Dimitrov	3R	J Wang	4R	M Raonic
	P-H Mathieu		A Nedovysev		D Kudla		L Saville		J-W Tsonga		K Nishikori
1R	A Haider-Maurer	1R	M Russell	1R	K De Schepper	2R	B Becker	3R	S Stakhovsky	4R	N Kyrgios
	K Edmund		J Reister		K Nishikori		A Dolgopolov		J Chardy		R Nadal
1R	B Tomic	1R	D Istomin	1R	R Gasquet	2R	L Mayer	3R	M Cilic	QF	N Djokovic
	E Donskoy		D Tursunov		J Duckworth		M Baghdatis		T Berdych		M Cilic
1R	V Hanescu	1R	F Lopez	1R	N Kyrgios	2R	A Kuznetsov	3R	A Murray	QF	A Murray
	T Berdych		Y Sugita		S Robert		D Ferrer		R Bautista Agut		G Dimitrov
1R	A Murray	1R	A Falla	1R	M Jaziri	2R	S Wawrinka	3R	K Anderson	QF	S Wawrinka
	D Goffin		A Pavic		G Monfils		Y-H Lu		F Fognini		R Federer
1R	P Andujar	1R	J Nieminen	1R	I Karlovic	2R	J Reister	3R	G Dimitrov	QF	M Raonic
	B Rola		F Delbonis		F Dancevic		D Istomin		A Dolgopolov		N Kyrgios
1R	T Kamke	1R	D Smethurst	1R	D Sela	2R	F Lopez	3R	L Mayer	SF	N Djokovic
	J Hernych		J Isner		M Kukushkin		A Pavic		A Kuznetsov		G Dimitrov
1R	S Johnson	1R	J Janowicz	1R	B Paire	2R	J Nieminen	3R	S Wawrinka	SF	R Federer
	R Bautista Agut		S Devvarman		L Rosol		J Isner		D Istomin		M Raonic
1R	K Anderson	1R	L Hewitt	1R	M Klizan	2R	J Janowicz	3R	F Lopez	F	N Djokovic
	A Bedene		M Przysiezny		R Nadal		L Hewitt		J Isner		R Federer

Ladies											
1R	S Williams	1R	V Zvonareva	1R	M Doi	2R	P Cetkovska	2R	M Doi	3R	C Garcia
	A Tatishvili		T Moore		E Svitolina		A Cornet		E Makarova		E Makarova
1R	C Scheepers	1R	Z Diyas	1R	K Date-Krumm	2R	A Petkovic	2R	M Larcher De Brito	3R	M Larcher De Brito
	C McHale		K Mladenovic		E Makarova		I-C Begu		J Gajdosova		A Radwanska
1R	J Jaksic	1R	S Zhang	1R	S Kuznetsova	2R	S Soler-Espinosa	2R	C Dellacqua	3R	P Kvitova
	P Cetkovska		C Suarez Navarro		M Larcher De Brito		E Bouchard		A Radwanska		V Williams
1R	A Schmiedlova	1R	A Ivanovic	1R	S Voegele	2R	A Kerber	2R	P Kvitova	3R	S Peng
	A Cornet		F Schiavone		J Gajdosova		H Watson		M Barthel		L Davis
1R	A Petkovic	1R	A Beck	1R	A Kontaveit	2R	L Dominguez Lino	2R	K Nara	3R	C Wozniacki
	K Piter		J Zheng		C Dellacqua		K Flipkens		V Williams		A Konjuh
1R	I Begu	1R	K Pliskova	1R	A Mitu	2R	A Riske	2R	M Kirilenko	4R	A Cornet
	V Razzano		K Knapp		A Radwanska		C Giorgi		S Peng		E Bouchard
1R	S Soler-Espinosa	1R	J Glushko	1R	P Kvitova	2R	T Bacsinszky	2R	L Davis	4R	A Kerber
	O Govortsova		S Lisicki		A Hlavackova		M Sharapova		F Pennetta		M Sharapova
1R	D Hantuchova	1R	K Koukalova	1R	K Nara	2R	S Halep	2R	C Wozniacki	4R	S Halep
	E Bouchard		T Townsend		A Friedsam		L Tsurenko		N Broady		Z Diyas
1R	A Kerber	1R	M Keys	1R	M Totto-Flor	2R	B Bencic	2R	A Konjuh	4R	S Lisicki
	U Radwanska		M Puig		V Williams		V Duval		Y Wickmayer		Y Shvedova
1R	H Watson	1R	Kr Piskova	1R	S Stephens	2R	D Vekic	2R	E Vesnina	4R	T Smitkova
	A Tomljanovic		Y Shvedova		M Kirilenko		V Zvonareva		B Zahlavova Strycova		L Safarova
1R	P Martic	1R	K Kanepi	1R	J Konta	2R	Z Diyas	2R	Y Meusburger	4R	E Makarova
	L Dominguez Lino		J Jankovic		S Peng		C Suarez Navarro		N Li		A Radwanska
1R	T Paszek	1R	V Azarenka	1R	J Cepelova	2R	A Ivanovic	3R	S Williams	4R	P Kvitova

	K Flipkens		M Lucic-Baroni		F Pennetta		J Zheng		A Cornet		S Peng
1R	A Pavlyuchkova	1R	J Larsson	1R	N Broady	2R	K Piskova	3R	A Petkovic	4R	C Wozniacki
	A Riske		B Jouvanovski		T Babos		S Lisicki		E Bouchard		B Zahlavova Strycova
1R	A Cadantu	1R	T Smitkova	1R	A Konjuh	2R	K Koukalova	3R	A Kerber	QF	E Bouchard
	C Giorgi		S-W Hsieh		M Erakovic		M Keys		K Flipkens		A Kerber
1R	T Bacsinszky	1R	C Vandeweghe	1R	Y Wickmayer	2R	Y Shvedova	3R	A Riske	QF	S Halep
	S Fichman		G Muguruza		S Stosur		K Kanepi		M Sharapova		S Lisicki
1R	S Murray	1R	L Safarova	1R	E Vesnina	2R	V Azarenka	3R	S Halep	QF	L Safarova
	M Sharapova		J Goerges		P Mayr-Achleitner		B Jovanovski		B Bencic		E Makarova
1R	S Halep	1R	P Hercog	1R	A Kudryyavtseva	2R	T Smitkova	3R	V Zvonareva	QF	P Kvitova
	T Pereira		P Ormaechea		B Zahlavova Strycova		C Vandeweghe		Z Diyas		B Zahlavova Strycova
1R	D Pfizenmaier	1R	M Niculescu	1R	V King	2R	L Safarova	3R	A Ivanovic	SF	E Bouchard
	L Tsurenko		A Van Utyvanck		Y Meusburger		P Hercog		S Lisicki		S Halep
1R	B Bencic	1R	A Wozniak	1R	P Kania	2R	A Van Utyvanck	3R	B Jovanovski	SF	L Safarova
	M Rybarikova		D Cibulkova		N Li		D Cibulkova		T Smitkova		P Kvitova
1R	V Duval	1R	S Errani	2R	S Williams	2R	C Garcia	3R	L Safarova	F	E Bouchard
	S Cirstea		C Garcia		C Scheepers		V Lepchenko		D Cibulkova		P Kvitova
1R	R Vinci	1R	T Pironkova								
	D Vekic		V Lepchenko								

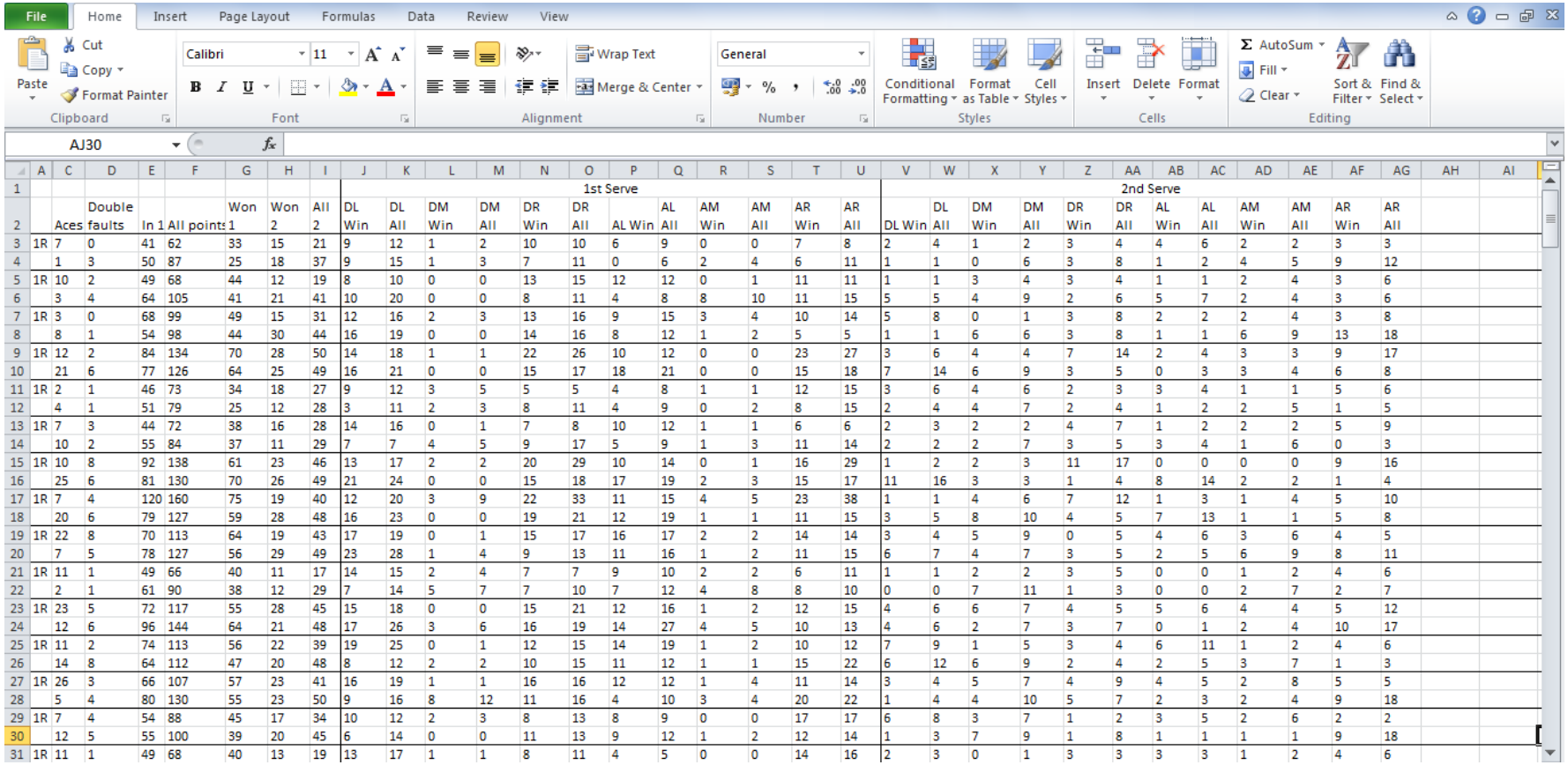
APPENDIX C

OPERATIONAL DEFINTIONS FOR THE ACTION VARIABLES USED IN THIS STUDY

Action Variable	Operational Definition
Aces	Serves which the returner cannot get their racket to before the second bounce, so the point goes straight to the server (O'Donoghue and Brown, 2008).
Double faults	When a legal serve is not completed in two attempts, the point is given to the returner (Chow *et al*., 2003).
Serves attempted	Each time the server makes contact with the ball at the start of the point, regardless of whether the ball lands "in" or not.
Serves that land "in"	Serves that are hit before the ball bounces, landing in the opposite diagonal service box (Matsuzaki, 2004).
Serving points won	Points which are won by the server after their 1st or 2nd serve lands "in".
Zone 1 serve	The service lands in the third of the service box closest to the inside tram line; "out wide" (Matsuzaki, 2004; Loffing, Hagemann and Strauss, 2009).
Zone 2 serve	The service lands in the middle third of the service box and at the height of the bounce it comes close to the player's body; "at the body" (Matsuzaki, 2004; Loffing, Hagemann and Strauss, 2009).
Zone 3 serve	The service lands in the third of the service box closest to the centre line; "down the T" (Matsuzaki, 2004; Loffing, Hagemann and Strauss, 2009).
Serving In / All %	The percentage of serves that land in compared to all serves attempted.
Serving Win / In %	The percentage of service points which are won compared to all serves which landed in.
Serving Win / All %	The percentage of service points that are won compared to all serves attempted.

APPENDIX D

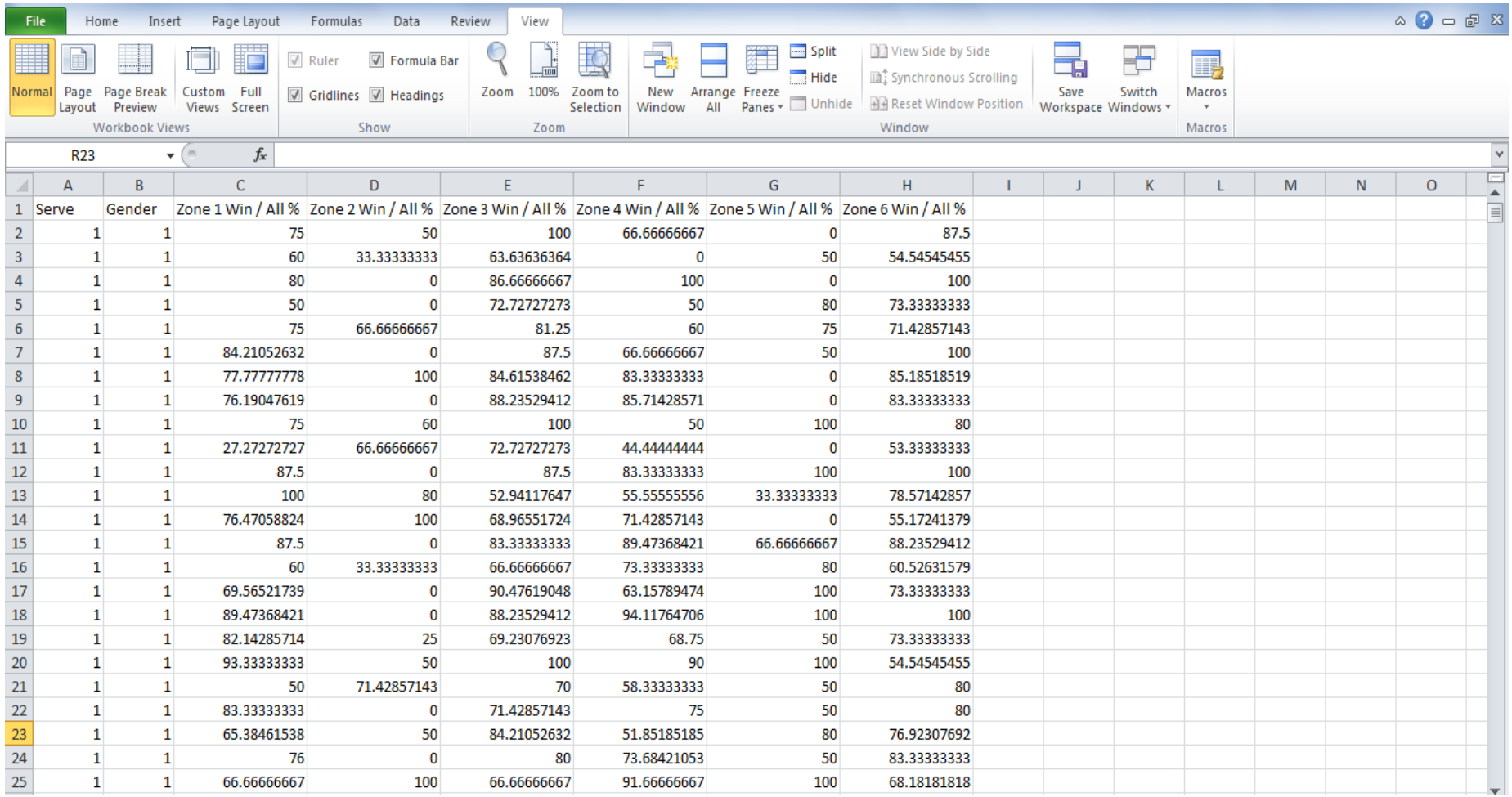
AN EXCEL SPREAD SHEET USED IN THIS STUDY TO INPUT WEB DATA INTO



									1st Serve												2nd Serve											
		Aces	Double faults	In 1	All points	Won 1	Won 2	All 2	DL Win	DL All	DM Win	DM All	DR Win	DR All	AL Win	AL All	AM Win	AM All	AR Win	AR All	DL Win	DL All	DM Win	DM All	DR Win	DR All	AL Win	AL All	AM Win	AM All	AR Win	AR All
3	1R	7	0	41	62	33	15	21	9	12	1	2	10	10	6	9	0	0	7	8	2	4	1	2	3	4	4	6	2	2	3	3
4		1	3	50	87	25	18	37	9	15	1	3	7	11	0	6	2	4	6	11	1	1	0	6	3	8	1	2	4	5	9	12
5	1R	10	2	49	68	44	12	19	8	10	0	0	13	15	12	12	0	1	11	11	1	1	3	4	3	4	1	1	2	4	3	6
6		3	4	64	105	41	21	41	10	20	0	0	8	11	4	8	8	10	11	15	5	5	4	9	2	6	5	7	2	4	3	6
7	1R	3	0	68	99	49	15	31	12	16	2	3	13	16	9	15	3	4	10	14	5	8	0	1	3	8	2	2	2	4	3	8
8		8	1	54	98	44	30	44	16	19	0	0	14	16	8	12	1	2	5	5	1	1	6	6	3	8	1	1	6	9	13	18
9	1R	12	2	84	134	70	28	50	14	18	1	1	22	26	10	12	0	0	23	27	3	6	4	4	7	14	2	4	3	3	9	17
10		21	6	77	126	64	25	49	16	21	0	0	15	17	18	21	0	0	15	18	7	14	6	9	3	5	0	3	3	4	6	8
11	1R	2	1	46	73	34	18	27	9	12	3	5	5	5	4	8	1	1	12	15	3	6	4	6	2	3	3	4	1	1	5	6
12		4	1	51	79	25	12	28	3	11	2	3	8	11	4	9	0	2	8	15	2	4	4	7	2	4	1	2	2	5	1	5
13	1R	7	3	44	72	38	16	28	14	16	0	1	7	8	10	12	1	1	6	6	2	3	2	2	4	7	1	2	2	2	5	9
14		10	2	55	84	37	11	29	7	7	4	5	9	17	5	9	1	3	11	14	2	2	2	7	3	5	3	4	1	6	0	3
15	1R	10	8	92	138	61	23	46	13	17	2	2	20	29	10	14	0	1	16	29	1	2	2	3	11	17	0	0	0	9	16	
16		25	6	81	130	70	26	49	21	24	0	0	15	18	17	19	2	3	15	17	11	16	3	3	1	4	8	14	2	2	1	4
17	1R	7	4	120	160	75	19	40	12	20	3	9	22	33	11	15	4	5	23	38	1	1	4	6	7	12	1	3	1	4	5	10
18		20	6	79	127	59	28	48	16	23	0	0	19	21	12	19	1	1	11	15	3	5	8	10	4	5	7	13	1	1	5	8
19	1R	22	8	70	113	64	19	43	17	19	0	1	15	17	16	17	2	2	14	14	3	4	5	9	0	5	4	6	3	6	4	5
20		7	5	78	127	56	29	49	23	28	1	4	9	13	11	16	1	2	11	15	6	7	4	7	3	5	2	5	6	9	8	11
21	1R	11	1	49	66	40	11	17	14	15	2	4	7	7	9	10	2	2	6	11	1	1	2	2	3	5	0	0	1	2	4	6
22		2	1	61	90	38	12	29	7	14	5	7	7	10	7	12	4	8	8	10	0	0	7	11	1	3	0	0	2	7	2	7
23	1R	23	5	72	117	55	28	45	15	18	0	0	15	21	12	16	1	2	12	15	4	6	6	7	4	5	5	6	4	4	5	12
24		12	6	96	144	64	21	48	17	26	3	6	16	19	14	27	4	5	10	13	4	6	2	7	3	7	0	1	2	4	10	17
25	1R	11	2	74	113	56	22	39	19	25	0	1	12	15	14	19	1	2	10	12	7	9	1	5	3	4	6	11	1	2	4	6
26		14	8	64	112	47	20	48	8	12	2	2	10	15	11	12	1	1	15	22	6	12	6	9	2	4	2	5	3	7	1	3
27	1R	26	3	66	107	57	23	41	16	19	1	1	16	16	12	12	1	4	11	14	3	4	5	7	4	9	4	5	2	8	5	5
28		5	4	80	130	55	23	50	9	16	8	12	11	16	4	10	3	4	20	22	1	4	4	10	5	7	2	3	2	4	9	18
29	1R	7	4	54	88	45	17	34	10	12	2	3	8	13	8	9	0	0	17	17	6	8	3	7	1	2	3	5	2	6	2	2
30		12	5	55	100	39	20	45	6	14	0	0	11	13	9	12	1	2	12	14	1	3	7	9	1	8	1	1	1	1	9	18
31	1R	11	1	49	68	40	13	19	13	17	1	1	8	11	4	5	0	0	14	16	2	3	0	1	3	3	3	3	1	2	4	6

APPENDIX E

AN ADAPTED EXCEL SPREAD SHEET WHICH WAS CONVERTED TO SPSS



File Home Insert Page Layout Formulas Data Review View

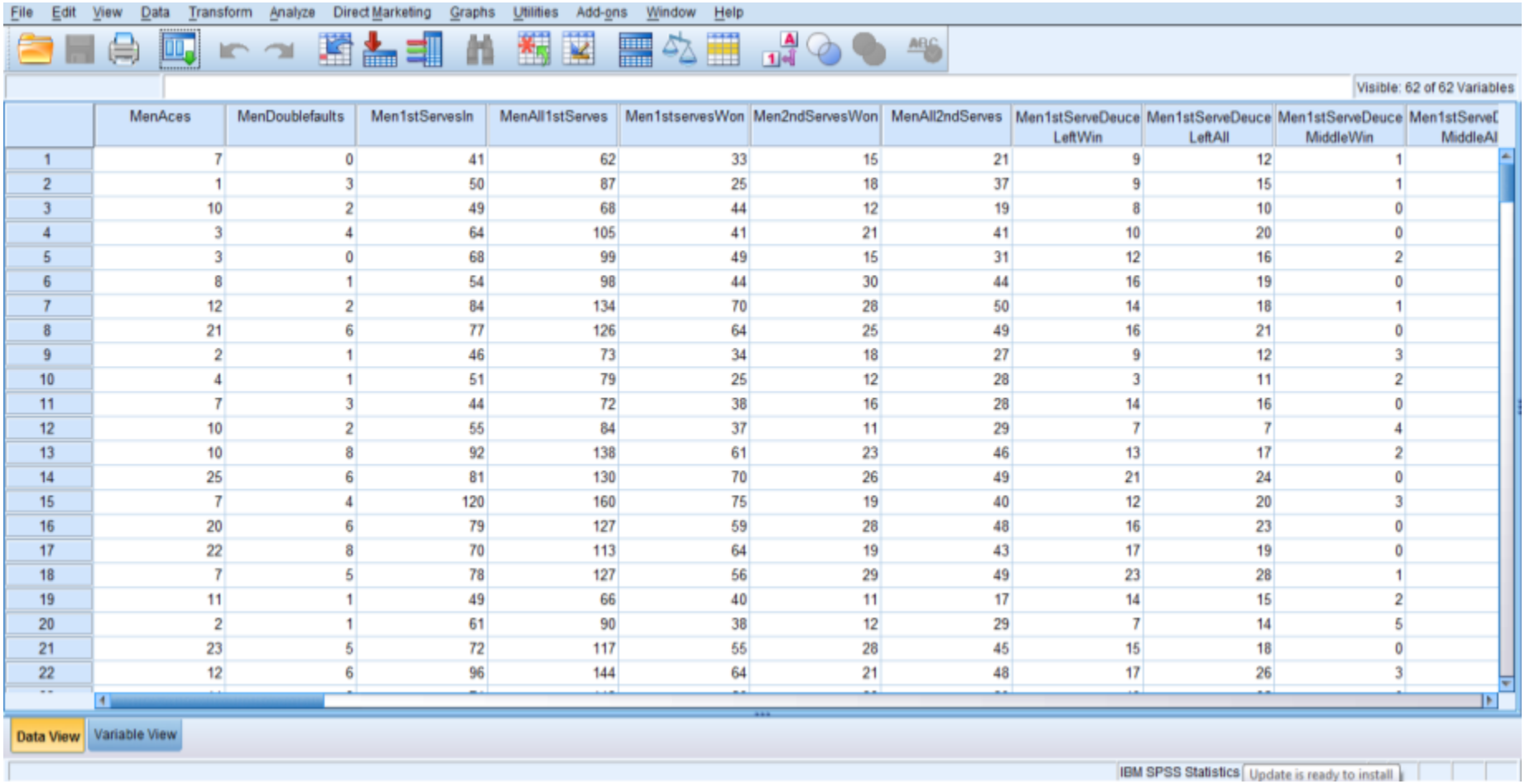
Normal Page Layout Page Break Preview Custom Views Full Screen — Workbook Views
Ruler Formula Bar Gridlines Headings — Show
Zoom 100% Zoom to Selection — Zoom
New Window Arrange All Freeze Panes Split Hide Unhide View Side by Side Synchronous Scrolling Reset Window Position — Window
Save Workspace Switch Windows — Macros

R23

	A	B	C	D	E	F	G	H
1	Serve	Gender	Zone 1 Win / All %	Zone 2 Win / All %	Zone 3 Win / All %	Zone 4 Win / All %	Zone 5 Win / All %	Zone 6 Win / All %
2	1	1	75	50	100	66.66666667	0	87.5
3	1	1	60	33.33333333	63.63636364	0	50	54.54545455
4	1	1	80	0	86.66666667	100	0	100
5	1	1	50	0	72.72727273	50	80	73.33333333
6	1	1	75	66.66666667	81.25	60	75	71.42857143
7	1	1	84.21052632	0	87.5	66.66666667	50	100
8	1	1	77.77777778	100	84.61538462	83.33333333	0	85.18518519
9	1	1	76.19047619	0	88.23529412	85.71428571	0	83.33333333
10	1	1	75	60	100	50	100	80
11	1	1	27.27272727	66.66666667	72.72727273	44.44444444	0	53.33333333
12	1	1	87.5	0	87.5	83.33333333	100	100
13	1	1	100	80	52.94117647	55.55555556	33.33333333	78.57142857
14	1	1	76.47058824	100	68.96551724	71.42857143	0	55.17241379
15	1	1	87.5	0	83.33333333	89.47368421	66.66666667	88.23529412
16	1	1	60	33.33333333	66.66666667	73.33333333	80	60.52631579
17	1	1	69.56521739	0	90.47619048	63.15789474	100	73.33333333
18	1	1	89.47368421	0	88.23529412	94.11764706	100	100
19	1	1	82.14285714	25	69.23076923	68.75	50	73.33333333
20	1	1	93.33333333	50	100	90	100	54.54545455
21	1	1	50	71.42857143	70	58.33333333	50	80
22	1	1	83.33333333	0	71.42857143	75	50	80
23	1	1	65.38461538	50	84.21052632	51.85185185	80	76.92307692
24	1	1	76	0	80	73.68421053	50	83.33333333
25	1	1	66.66666667	100	66.66666667	91.66666667	100	68.18181818

APPENDIX F

AN EXAMPLE OF THE SPSS SPREAD SHEET USED IN THIS STUDY TO COLLECT OUTPUT RESULTS



	MenAces	MenDoublefaults	Men1stServesIn	MenAll1stServes	Men1stservesWon	Men2ndServesWon	MenAll2ndServes	Men1stServeDeuceLeftWin	Men1stServeDeuceLeftAll	Men1stServeDeuceMiddleWin	Men1stServeDMiddleAl
1	7	0	41	62	33	15	21	9	12	1	
2	1	3	50	87	25	18	37	9	15	1	
3	10	2	49	68	44	12	19	8	10	0	
4	3	4	64	105	41	21	41	10	20	0	
5	3	0	68	99	49	15	31	12	16	2	
6	8	1	54	98	44	30	44	16	19	0	
7	12	2	84	134	70	28	50	14	18	1	
8	21	6	77	126	64	25	49	16	21	0	
9	2	1	46	73	34	18	27	9	12	3	
10	4	1	51	79	25	12	28	3	11	2	
11	7	3	44	72	38	16	28	14	16	0	
12	10	2	55	84	37	11	29	7	7	4	
13	10	8	92	138	61	23	46	13	17	2	
14	25	6	81	130	70	26	49	21	24	0	
15	7	4	120	160	75	19	40	12	20	3	
16	20	6	79	127	59	28	48	16	23	0	
17	22	8	70	113	64	19	43	17	19	0	
18	7	5	78	127	56	29	49	23	28	1	
19	11	1	49	66	40	11	17	14	15	2	
20	2	1	61	90	38	12	29	7	14	5	
21	23	5	72	117	55	28	45	15	18	0	
22	12	6	96	144	64	21	48	17	26	3	