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Tennis ready position and total body movement time involved in the forehand return of service

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TENNIS READY POSITION AND TOTAL BODY MOVEMENT TIME INVOLVED IN THE FOREHAND RETURN OF SERVICE

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Tennis Ready Position and Total Body Movement Time Involved in the Forehand Return of Service (41pp.)

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This research investigated five different ready positions for the tennis return of service to determine if any one position allowed the athlete to decrease movement time. The positions were analyzed by total body movement time as measured by the time it took an athlete to complete his first step (lead foot movement ceases - heel upon playing surface) towards a served ball. Ten male and ten female skilled tennis athletes with high school or college playing experience served as subjects. The conclusions from this study were: (1) there was no significant difference in total body movement time between the positions tested, therefore, the teaching of the tennis return of service ready position should be taught to conform to each individual player's needs, (2) there was no significant difference in total body movement time between the sexes tested, therefore, there is no need to teach a different return of service to males as opposed to females, (3) there was no significant difference in total body movement time between the positions and the sexes, therefore, males are not quicker out of a particular return of service ready position than females, and females are not quicker out of a particular return of service ready position than males, and (4) the subjects tested in this study were not the most reliable source of information concerning their total body movement times when performing the five different return of service ready positions, thus concluding that subjects may not be reliable sources of information when dealing with body movements.

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CHAPTER I

INTRODUCTION

Due to rapid changing stimuli in many sports activities, the postural position of the body must adjust quickly to the situation for an optimal performance. From the upright or ready stance, an athlete is nearly always required to shift his body position forward, backward, or laterally.

Hay (1973) has stated that to be effective, an athlete must be able to outmaneuver an opponent with rapid changes in speed and direction of movement. In attempting to achieve these objectives--whether starting from a stationary position, coming to a stop, or merely changing the speed or direction of movement, an athlete must exert forces to accelerate (or decelerate) his body. The magnitude and direction of these forces determine the nature of the acceleration that he experiences (Newton's second law). It is, therefore, of importance that the athlete assume a position from which he can readily apply forces that are consistent with his needs. Because these forces result mainly from the action of muscles in the athlete's legs and are transmitted to the floor via his feet, the position of his legs and feet are especially important.

In no other strokes in tennis is the proper ready position

more crucial than in the return of service. According to Braden (1977) the service return is the second most important shot in the game. The third, fourth, and fifth shots become important only if you make an effective return of service.

The ready position consists of the athlete's body weight and movement in a balanced state. When starting from a balanced position, if the athlete's state of equilibrium is disrupted easily, his movement time will be decreased thus enabling him to move in any given direction more rapidly. Therefore, in the tennis return of service ready position, if the athlete involved can disrupt his equilibrium state easier using a specific ready position it should be promoted to enhance performance.

Statement of the Problem

This research proposes to evaluate five different ready positions for the tennis return of service to determine if any one position allows the athlete to decrease movement time. The positions will be analyzed by total body movement time as measured by the time it takes an athlete to complete his first step (lead foot movement ceases--heel upon playing surface) towards a served ball.

The Hypothesis

The hypothesis is that none of the five different ready positions for the return of service will have any significant effect on total movement time.

The alternative hypotheses are:

1. The ready position of knees bent-feet flat results in a significantly faster movement time.

2. The ready position of knees bent-weight on balls of feet results in a significantly faster movement time.

3. The ready position of knees straight-feet flat results in a significantly faster movement time.

4. The ready position of knees straight-weight on balls of feet results in a significantly faster movement time.

5. The ready position of knees bent-weight on balls of feet jumping up and down results in a significantly faster movement time.

6. A significant difference of total body movement times

will be found between sexes tested (male, female).

Definition of Terms

Movement time. The time it takes to move from a ready position to the completion of the first step (lead foot movement ceases--heel upon playing surface) taken towards a served tennis ball.

Ready position. Any upright position that will enable an athlete to move in any given direction as quickly as possible.

Skilled tennis athlete. Any tennis athlete who can perform the basic and advanced strokes of the game with a high level of proficiency.

CHAPTER II

REVIEW OF RELATED LITERATURE

There has been a scarcity of studies undertaken concerning total body movement time for a given task. It should be noted that the subject to be dealt with is total body movement time, not reaction time.

This review, dealing with the tennis ready position and movement time involved in return of service, shall examine only the aspects of total body movement time, the tennis return of service, and the ready positions involved in the return of service.

Movement Time Related to Athletic Success

Keller (1942), studied the relation of quickness of bodily movement to success in athletics. The purpose of this study was to compare quickness of bodily movement in a general sense to athletic success rather than to determine the relationship between specialized techniques of certain sports and successful participation in those sports. It was first necessary to select for measurement, movements of a general nature that were rather common to most sports. Analysis of the more common sports verified that, for the most part, quick movements were required in three directions,

namely, forward, to the right, and to the left. Seldom was the competitor called on to move quickly backward. Most maneuvers were combined arm, leg, and trunk movements, directly forward or to the side. Subjects stood in a relaxed but alert position, with feet slightly spread and hands on knees. On visual signals of lighted arrows, the subjects would move through a specified distance throwing a target switch which measured the total movement completion time to the nearest 1/100 of a second. A total of thirty-six measurements were taken on each subject. Eighteen of the movements were made by the subject when he did not know which direction he would move and the other half of the measurements were made when the subject was told in which direction he/she was to move. The arithmetic mean of the thirty-six measurements was the statistic which represented the quickness of body movement. A total of 755 men and boys participated in the study. All subjects were placed in one of two main catagories, namely, athletes and non-athletes. Athletic success was determined by two methods of rating, one of which was based upon performance and the other upon estimates by coaches and physical education teachers. All subjects were given a rating and then placed into the two pre-determined catagories. The following statistical comparisons were made:

1. The quickness scores of athletes were compared with those made by men classed as non-athletes.

2. The relationship between quickness and athletic performance ratings and between quickness and coaches' ratings

were calculated by means of contingency tables and the resulting coefficients of contingency. Comparison of the scores made by the athletes and non-athletes indicated that the athletes as a group scored significantly better than the non-athletes.

Conclusions of the study stated that there is a positive relationship between the ability to move the body quickly and success in athletic activities. It was also concluded that the requirements in quickness of bodily movement are not the same for all sports. An individual with slower movement time would be better off in activities such as gymnastics, swimming, or wrestling than in sports in which he/she is required to react to rapidly changing conditions such as football, basketball and baseball.

McLane (1966), compared lateral starting times recorded by subjects under conditions of body position, direction, and initial step. Two different body positions were investigated: a slight crouch and a deep crouch. Lateral starts were made to the right and to the left. The two initial steps investigated were an open step and a cross-over step. Forty male students from the University of Arkansas served as subjects. Each subject performed forty-eight starts. Conclusions indicated that the amount of body crouch (slight or deep), type of initial step (open or cross-over), and direction (left or right), had no significant effect upon a lateral start of three yards.

Slater-Hammel (1953), studied the effect of initial body position upon total body reaction time of sixteen male physical education majors. Body positions were varied by the distribution of body weight and the position of the knees. The four positions studied were:

A. Knees straight with weight distributed over feet

B. Knees straight with weight on balls of feet

C. Knees bent with weight distributed over feet

D. Knees bent with weight on balls of feet.

No controls were placed upon the degree of knee bending. Each subject was permitted to bend his knees to the degree he felt most effective. In all four starting positions the feet were parallel, the body was bent forward, and the hands were placed in front of the body.

Total body reaction time was measured by instructing the subject to stand on the contact plates in one of the four starting positions. After a "ready" signal was given, the subject would concentrate on the two lights in front of him. When one of the lights appeared, the subject would step diagonally forward with the foot indicated by the light. Twenty-five reaction times were measured for each starting position.

Results of the study concluded that reaction times of the starting positions with the weight distributed over the feet were significantly shorter than the reaction times of the positions with the weight over the balls of the feet. Position of the knees had no significant effect on starting

reaction times.

A post-experiment study of the changes of weight distribution revealed that most subjects consistently rocked back on their heels in completing a reaction. It was suggested that starting reactions from the balls of the feet require more time because the time required to lower the heels to the floor was included in the reaction time.

Cotten and Denning (1970), retested the findings of Slater-Hammel. The four variations of the upright starting position were used. The same basic method of testing was also duplicated with slight variations.

Results of the Cotten and Denning study revealed that of the four upright positions the reaction movement times associated with the two knees straight variations were always slower than those from the knees bent positions. When comparing the knees bent stance, it was noted that the fastest reaction-movement times were always obtained from the feet flat stance. It was also noted that from the stance with the weight on the balls of the feet each subject tended to rock back on his heels before moving in the desired direction. This observation also supported Slater-Hammel's post-experiment study. It was concluded that the weight on the balls of the feet position required more reaction-movement time due to the rocking back on the heels movement. It was also suggested that the feet flat, knees bent stance is the best choice for optimum reaction-movement time.

Hodgkins (1963), noted that males are faster than females in movement time. The speed of movement time increases until early adulthood and then decreases. However, peak movement time speed is maintained longer by males than females.

Footwork and the Return of Service Ready Position

In tennis, Segura (1976) has stated that good footwork on a court accounts for speed in reacting to a moving ball, proper balance when one gets to the target, and the vital weight transfer just before the hit that gives power to the shot. Tilden (1962) has indicated that footwork is the means for perfect weight control and balance. Good footwork is the major contributor to success in various sports. He has also stated that perfect timing is dependent upon footwork.

For an athlete to incorporate these elements into his game plan it is essential for him to obtain the proper ready position. Braden (1977) has stated that there is no universal ready position--only that position that will get you to the ball the fastest. In no other stroke in tennis is the proper ready position more crucial than in the return of service. According to Braden, the service return is the second most important shot in the game. The third, fourth and fifth shorts become important only if you make an effective return of serve.

Experts (Barnaby (1975), Bassett (1977), Braden (1977), Eldred (1975), Fiske (1970), Gonzales (1962), Johnson and

Xanthos (1967), King (1970), Kodes (1975), Mottram (1976)) in the game of tennis have basically agreed on how the athlete should initiate the return of service ready position. They suggest that the proper position is one of the feet twelve to fourteen inches apart, knees slightly flexed, weight distributed over the balls of the feet, and with the body leaning forward. This position is supposed to enable the athlete to get a quick first step towards the ball when receiving the serve.

An alternative ready position suggested by Brunson (1979), Smith (1975), and Segura (1976), stated that the same position as previously mentioned should be used but with a jumping up and down on the toes motion to ensure a quick step towards the ball.

CHAPTER III

METHODOLOGY

Pilot Study

On January 29, 1980, a pilot study was undertaken with one male tennis athlete to test the operating procedures for the main study. The indoor tennis court at the University of Montana was used to check light source and overall set-up for filming and equipment (Appendix A). Equipment used consisted of a Prince Standard tennis ball pitching machine with serving attachment, three dozen Wilson optic yellow extra duty tennis balls, a Canon Scoopic model 16 mm motion picture camera filming at 64 frames per second (f.p.s.), and two rolls of Kodak 4-X Reversal film.

The subject was first given a brief verbal explanation about the five return of service ready positions to be tested, and any questions he had concerning the positions were answered. The subject was then asked to stand where he would normally to receive a serve to his forehand side. The first ready position of knees straight-feet flat (KS-FF) was randomly selected from the five positions to be tested. It was then explained to the subject that his position consisted of standing in an upright stance with the knees locked, feet hip width apart and flat upon the playing surface.

The subject was then asked to practice moving out of this position to an imaginary ball. When it was felt by mutual agreement of the subject and the tester that performance of the position was satisfactory, the testing began.

Testing procedures in the pilot sutdy consisted of three practice trials in the position selected with the ball machine serving. After the trials were completed the next five balls served were filmed with the Canon 16 mm camera at 64 f.p.s. from a position sixteen feet behind the back court baseline. Upon completion of filming, a short rest period was taken. After the rest period the next position was explained, practiced, and filmed. This procedure was repeated for each of the positions.

The remainder of the five positions not previously explained are as follows:

A. Knees Straight-Weight on Balls of Feet (KS-WB)

Subject standing in an upright position with knees locked, feet hip width apart with weight distributed over balls of feet so heels are slightly raised from playing surface.

B. Knees Bent-Feet Flat (KB-FF)

Subject standing in an upright position with knees flexed (comfortable--no less than 5^{o}--no more than 25^{o}), feet hip width apart and flat upon playing surface.

C. Knees Bent-Weight on Balls of Feet (KB-WB)

Subject standing in an upright position with knees flexed (comfortable--no less than 5^{o}--no more than 25^{o}),

feet hip width apart with weight distributed over balls of feet so heels are slightly raised form playing surface.

D. Knees Bent-Weight on Balls of Feet-Jumping (J)

Subject standing in an upright position with knees flexed (comfortable--no less than 5^{o}--no more than 25^{o}), feet hip width apart with weight distributed over balls of feet so heels are slightly raised from playing surface. Subject will be jumping up and down to enable feet to leave the playing surface slightly.

Upon completion of filming the five ready positions, the film was processed and then analyzed with a Lafayette Rear Screen Analyzer. Movement time for each position was calculated by counting the number of frames of film from visual contact of the ball coming out of the serving tube to the point when the subject completed his first step towards the ball. By dividing the number of frames which movement occured by the film speed (64 f.p.s.), movement time was then derived.

$$\frac{X}{64 \text{ f.p.s.}} = \text{movement time (seconds)}$$

Data was then arranged to see if five, four, or three trials for each position were needed. By using a Spearman Rho rank order correlation it was concluded that three trials for each position would give the same results as four or five trials. Thus, it was decided that three trials for each position would be filmed for the study.

A question was raised from the pilot study concerning the

reaction times of the athlete. It was hypothesized that the subject's reaction time would differ in each position because of anticipation of the ball being served from the machine, thus affecting total body movement time. Reaction times of the subject were then derived from the pilot film and found to be virtually the same for each trial for each position. Therefore, the idea of measuring reaction times in addition to total body movement times was abandoned.

As a result of the pilot study and reduction of the pilot film, only one change and two additions, to the testing procedure were adopted. The rest period between the filming of each position was abandoned because it was felt that the subjects were not fatigued enough to receive one. If a subject were to request a rest period, one would have been granted.

The first addition consisted of taping an area (4.5' X 5') on the court surface in which the subjects were to stand to begin each trial. This was done to prevent the subjects from moving to different locations on the court (Appendix A). The second addition involved a survey conducted by the investigator at the end of each subject's filming session. Questions asked included:

(a) Which of the five ready positions felt quickest to you?

(b) Which of the five ready positions felt slowest to you?

(c) Which of the five ready positions most resembled your own?

Research Design

The research design used in this study was experimental. Five treatments (ready positions) were performed by each subject who was a member of one of two groups (male, female). The independent variables involved in this study were the five ready positions. The dependent variable was the amount of time to perform the movement out of the ready position.

Subjects

Subjects for the study consisted of ten male and ten female skilled tennis athletes. All subjects were randomly selected from the tennis population of high school and college varsity tennis players, and tennis players with high school and college varsity experience who had not reached their thirty-first birthday. All subjects were currently residing in Missoula, Montana. For each group, five alternates were selected in case a subject was unable to attend a filming session. Age of the subjects ranged from seventeen to thirty. Skilled athletes were used to eliminate the factor of having to teach the return of service.

Instrumentation

The following instruments, materials, and facilities were used in the study.

1. Indoor tennis court--University of Montana
2. Prince Standard tennis ball machine with serving attachment. Machine was located 2' behind and 2' to the

right of the center service line. Ball speed was set at 60 m.p.h.

3. Canon Scoopic 16 mm motion picture camera--located 7' to the left of the right singles side line and 18.5' behind the back baseline. (Appendix A).

4. Kodak 16 mm 4X Reversal film--1,200'

5. Wilson optic yellow extra duty tennis balls--36

6. Nissen score keeper

7. Lafayette Rear Screen Analyzer

Testing Procedures

1. Subjects read and signed a consent form (Appendix G).

2. The return of service ready positions were verbally explained to each subject. Any questions concerning the positions were answered.

3. Subjects were exposed to 20 practice serves from the machine to familiarize them with the machine and court surface.

4. Ready positions were randomly assigned for order to be filmed (Appendix B).

5. Before filming, each ready position was explained and demonstrated by the test administrator. The subject then practiced the position until it was felt by mutual agreement by subject and tester that performance of the position was satisfactory.

6. Subjects reacted to five served tennis balls--the final three of which were filmed.

7. Upon completion of filming the five positions, each subject was asked the following questions:

(a) Which of the five ready positions felt quickest to you?

(b) Which of the five ready positions felt slowest to you?

(c) Which of the five ready positions most resembled your own?

Data Reduction and Statistical Analysis

Filmed data were reduced by use of a Lafayette Rear Screen Analyzer. Movement time for each subject was calculated from the frame of film which the ball was first observed exiting the serving tube, to the frame of film when the subject completed his/her first step (lead foot movement ceased--heel upon playing surface) towards the ball. By counting the number of frames between the two points and dividing this number by the film speed, movement time was derived.

$$\frac{\text{Frames of Film}}{\text{Film Speed}} = \text{Movement Time}$$

Film speed was calculated by filming a dropped ball from three feet above the court surface. By use of the formula for deriving the time it takes a free falling object to land from a given height ($d = V_i t + 1/2\ at^2$), a time of .4317 was calculated. By counting the number of frames of film it took the ball to hit the court surface from release, and dividing by the time it takes to fall due to gravity (.4317),

film speed was derived.

$$\frac{\text{Frames of Film}}{.4317} = \text{Film Speed}$$

Film speed was calculated at three different times during the study and was found to be a constant 62 frames per second.

Movement times were analyzed by a 2 (male, female) X 5 (ready positions) Analysis of Variance. A Pearson Product Moment Correlation Coefficient was used to test the reliability of the investigator's ability to reduce data consistently from the film.

Methodological Assumptions

The following methodological assumptions were assumed:

1. Random order of assignment of the five positions did negate influence of one position over another due to preference or fatigue.

2. Fatigue was not a factor in movement times of the positions tested.

3. Each subject did give his/her best effort.

4. The equipment used in this study was of high quality, therefore, data collected were reliable.

Limitations

Limitations of this study included the fact that the subjects may not have had enough time to practice the ready positions to completely eliminate subject bias introduced by

subject preference of a ready position. Another limitation of this study was that the subjects were subjected to a machine rather than human server. Ball placement to the forehand side only may have decreased movement time due to anticipation by the subjects. Performance may have been influenced by the poor lighting of the tennis court.

Delimitations

Non-controllable factors which were present in this study included the skill differences between the subjects and diurnal variations. Poor health, amount of activity the subject was involved in prior to testing, and the general attitude of the subject towards the study could not have been completely controlled.

CHAPTER IV

ANALYSIS AND DISCUSSION OF DATA

Analysis of Data

This study was concerned with the tennis ready positions and total movement time involved in the forehand return of service. The conclusions of this investigation were drawn from the results of the analysis of the raw data found in Appendices C and D.

The statistical tool used to arrive at an answer to the question of whether there was a significant difference of total body movement time between the five different ready positions was a 2 X 5 Analysis of Variance (ANOVA). The two groups consisted of male and female skilled tennis athletes, with each member of each group performing the five different ready positions. The completed ANOVA appears in Table I.

Upon examination of the data collected, it was concluded that there was no significant difference among the five ready positions investigated in this study, between men and women, or among the five ready positions and the two groups. Therefore, the null hypothesis was accepted, and the alternate hypotheses were rejected.

To test the reliability of the investigator's ability

TABLE I

Analysis of Variance of Movement Times for Five Return of Service Ready Positions by Sex (M, F)

Source of Variation	df	SS	MS	F
A (Positions)	4	.0215	.0054	.9153
B (Sex (M,F))	1	.0061	.0061	1.0339
AB (Positions, Sex)	4	.0069	.0017	.2881
Error (Within Groups)	95	.5493	.0059	

$F_{(.05)}^{4,95} \geq 3.54$

$F_{(.05)}^{1,95} \geq 6.93$

to be consistent in reducing film readings, a Pearson Product Moment Correlation Coefficient was computed (Appendix E). Readings were recalculated for the first trial of the third position for each subject three days following the initial reduction of data. The figures from the two separate analyses were correlated. A correlation of .92 was obtained which indicated that a high degree of reliability was achieved.

Data collected from the survey conducted at the completion of each subject's filming session suggested that in all cases for each question asked, the responses differed greatly from the actual performance of the subject (Appendix F). No specific statistical tools were used, only a comparison of responses to performance times.

Discussion of Data

There can be no specific reasons cited for the lack of statistical significance in the study completed--only educated assumptions. From previous research, it was assumed that total body movement time would differ significantly for each of the five return of service ready positions. Slater-Hammel (1953) and Cotten and Denning (1970) concluded that the position of knees bent-feet flat was significantly quicker than other positions tested. However, the movements out of their positions were non-specific; subjects reacting to a light stimulus rather than a specific sport cue. The findings of their study were drawn from body reaction times as opposed to total body movement times. Data reduced from the pilot film of this study concluded that reaction times were virtually the same for all positions thus conflicting greatly with the study presently cited.

The post-experiment study by Slater-Hammel and Cotten and Denning noted that most of the subjects tested consistently rocked back on their heels when completing movements out of the positions of weight distributed over the balls of the feet. This was not found to be true for 55% of the subjects tested in the return of service ready position of knees straight-weight on balls of feet, but was found to be true for 55% of the subjects tested in the return of service ready position of knees bent-weight on balls of feet. Due

to these non-convincing statistics reduced from the film, it has been demonstrated in this study that the heel-rock movement may or may not take place for both positions tested.

McLane (1966) compared lateral starting times recorded by subjects under conditions of body crouch, type of inital step, and direction. No significance was found between body position, movement, and direction, which contradicts the findings of Slater-Hammel and Cotten and Denning, but supports the findings of this study in matters of body position and movement.

Hodgkins (1963) noted that males are faster than females in total body movement time. The findings of this study, however, concluded that there was no significant difference of total body movement time between males and females.

From the literature cited by tennis experts (Barnaby (1975), Bassett (1977), Eldred (1975), Fiske (1970), Gonzales (1962), Johnson and Xanthos (1967), King (1970), Kodes (1975), Mottram (1976)), the return of service ready position should be that of feet twelve to fourteen inches apart, knees slightly flexed, weight distributed over the balls of the feet, and with body leaning forward. An alternative ready position suggested by Brunson (1979), Smith (1975), and Segura (1976), stated that the same position as previously mentioned should be used, but with a jumping up and down on the toes motion. From the data collected in this study, it was concluded that none of the five return of service ready positions tested

(including the two previously cited) were significantly quicker than any other in total body movement time. An examination of mean movement times for all positions tested showed that neither the position of knees straight-weight on balls of feet or knees bent-weight on balls of feet-jumping resulted in the quickest total body movement time. It was also shown that 78% of the subjects tested in the jumping position did not stop jumping in anticipation towards the served ball.

Braden's (1977) concept of the return of service ready position, which has been stated as any position which the player feels can get him to the ball the quickest, was inspected through a survey conducted at the end of each subject's filming session. It was observed from all subjects questioned, that only 30% could tell from which position they performed their quickest total body movement time. Conversely, from all subjects questioned, only 25% could tell in which position they performed their slowest total body movement time. Also, only 25% of all subjects questioned performed their quickest total body movement time towards the served tennis ball out of the ready position which they felt most resembled their own (Appendix F).

From the previous studies and literature cited, it is in this researcher's opinion that the optimal return of service ready position is that of any position that the player feels will get him to the ball quickest. This idea

is also what Braden has stated, even though the survey conducted at the end of each subject's filming sessions concluded that the subjects themselves could not tell which position was quickest for them. The old saying of "if it feels good--do it" could be adopted for teaching the return of service ready position.

The subjects in this study were skilled tennis athletes. Future studies in this area might want to incorporate the use of beginning tennis athletes and train them in the different positions for a certain length of time. By using and training beginners, instead of skilled tennis athletes, perhaps significance could be found between the positions tested due to a lack of personal bias towards a certain movement or position.

One of the limitations of this study was the placement of all served tennis balls to the subject's forehand side. The reason for this being done was that the machine used did not have the capability of randomly alternating the serves to either the forehand or backhand side. The use of a human server would have been optimal, but consistency of ball placement and service speed probably could not have been achieved due to human error. If human error could have been controlled, subjects would not have known to which side the ball would be placed, bringing in an element of hesitance, which could have increased or decreased total body movement times. With a higher degree of variance in total body movement times, significance might have occurred.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

On the basis of the results collected, and within the limitations of this study, the following conclusions have been made:

1. There is no significant difference in total body movement time between the positions tested in this study, therefore, the teaching of the tennis return of service ready position should be taught to conform to each individual player's needs.

2. There is no significant difference in total body movement time between the sexes (male, female) tested in this study, therefore, there is no need to teach a different return of service ready position to males as opposed to females.

3. There is no significant interaction in total body movement time between the positions and sexes tested in this study, therefore, males are not quicker out of a particular return of service ready position than females, and females are not quicker out of a particular return of service ready position than males.

4. The subjects tested in this study were not the most reliable source of information concerning their total body movement times when performing the five different return of service ready positions, thus concluding that subjects may not be reliable sources of information when dealing with body movements.

Recommendations

In retrospect of this study, the following recommendations have been made:

1. The use of an actual human server to cancel any mechanical limitations.

2. The use of non-skilled tennis athletes, training them over a certain length of time for each position, to see if any significance would occur among the five different positions.

3. Without letting the subject know in advance to include the element of unexpectedness, the use of a tennis ball machine which could serve a ball to either the forehand or backhand side.

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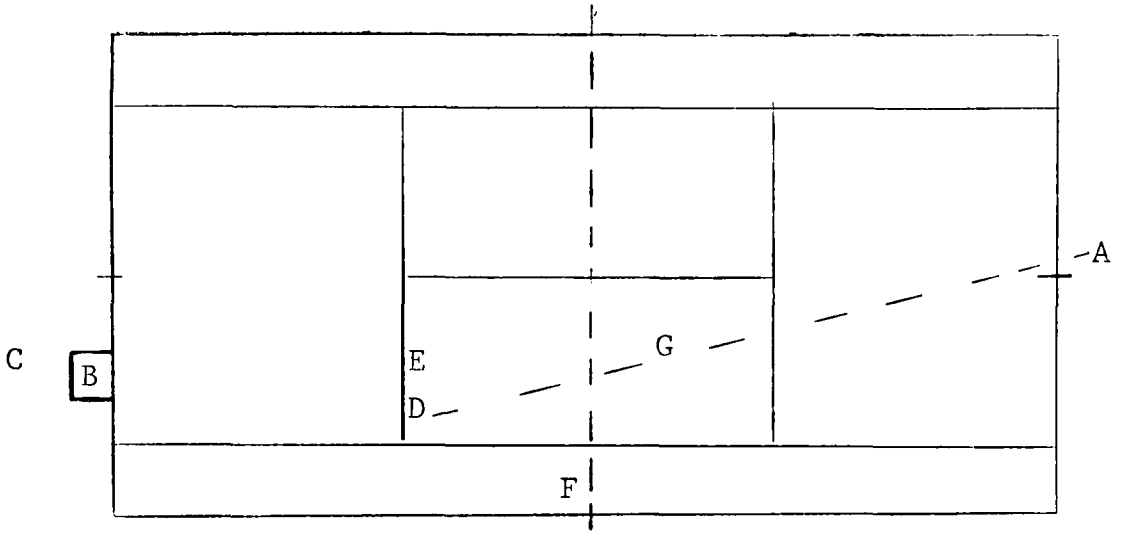
APPENDICES

APPENDIX A

INSTRUMENTATION SET-UP



A Position of ball machine--2' behind and 2' to the right of the center service mark.

B Position of subject--inside taped area (4.5' X 5'), 4' from right singles sideline.

C Position of camera--7' left of right singles sideline, 18.5' from baseline.

D Ball placement position for right handed subjects--9' from right singles sideline, 1.5' towards net from service line.

E Ball placement position for left handed subjects--9' from right singles sideline, 1.5' towards net from service line.

F Position of Nissen scorekeeper

G Path of served tennis ball--69'

APPENDIX B

ORDER OF POSITIONS FOR FILMING
March 3-6, 1980

	POSITIONS	
NUMBER	MALE	FEMALE
1	4-3-1-2-5	5-1-4-2-3
2	2-5-1-3-4	1-4-2-3-5
3	3-5-1-2-4	2-3-1-5-4
4	1-3-4-5-2	1-4-3-2-5
5	4-3-5-2-1	5-1-2-3-4
6	5-3-4-1-2	1-4-3-5-2
7	3-4-1-2-5	2-3-1-4-5
8	2-5-1-3-4	3-4-2-1-5
9	3-2-4-5-1	1-2-3-5-4
10	4-3-1-5-2	4-5-3-1-2

1 = KS-FF

2 = KS-WB

3 = KB-FF

4 = KB-WB

5 = J

APPENDIX C

RAW DATA--MALE

SUBJECT	TRIAL	POS 1	POS 2	POS 3	POS 4	POS 5
1	1	1.0322	.9677	1.0161	1.0484	1.3226
	2	1.1061	1.0161	1.0323	1.0968	.9839
	3	1.0327	.9677	1.0484	1.0967	.9032
	$\bar{x}$	1.0269	.9839	1.0323	1.0806	1.0699
2	1	.9839	1.0000	.9839	.9677	1.0645
	2	.9678	1.0000	.9198	.9839	.9355
	3	.9839	.9839	.9516	.9516	.9194
	$\bar{x}$	.9785	.9946	.9516	.9677	.9731
3	1	.9516	.9839	1.0645	.9032	1.1452
	2	1.0323	.9516	.9516	1.0161	.9839
	3	.9677	.9194	.9839	.9839	1.0161
	$\bar{x}$	.9839	.9516	1.0000	.9677	1.0484
4	1	1.0484	.9677	.9839	.9516	.9677
	2	.9839	1.0323	1.0000	1.0161	.9194
	3	1.0161	.9677	1.0645	1.0484	.9194
	$\bar{x}$	1.0161	.9892	1.0161	1.0054	.9355
5	1	1.0323	1.0323	1.0645	.9032	1.0806
	2	1.0484	.9677	1.0806	1.0806	1.0968
	3	1.0323	1.0323	1.0806	1.0968	1.1290
	$\bar{x}$	1.0376	1.0108	1.0753	1.0269	1.1022
6	1	1.0161	.9355	1.0323	.8871	.9355
	2	1.0161	.9194	1.0000	.9839	1.0000
	3	1.0000	.9194	1.0000	.9516	1.0000
	$\bar{x}$	1.0108	.9247	1.0108	.9409	.9785
7	1	1.0806	1.0484	.9677	.9677	1.0161
	2	1.0161	1.0484	1.0000	1.0161	1.0484
	3	1.0484	.9677	1.0645	.9677	1.0323
	$\bar{x}$	1.0484	1.0215	1.0108	.9839	1.0323
8	1	1.1129	1.1452	1.1452	1.0645	1.0000
	2	1.0806	1.0645	1.0968	1.1129	1.1613
	3	1.1935	1.0968	1.1452	1.0645	1.1452
	$\bar{x}$	1.1290	1.1022	1.1290	1.0806	1.1022

SUBJECT	TRIAL	POS 1	POS 2	POS 3	POS 4	POS 5
9	1	1.0968	1.0000	1.0806	1.0161	1.0806
	2	1.0484	.9032	1.0968	1.0806	1.1290
	3	1.1129	1.0968	1.0323	1.0484	1.2097
	$\bar{x}$	1.0860	1.0000	1.0699	1.0484	1.1398
10	1	.9677	.9839	.9677	.9516	.9194
	2	1.0000	.9032	.9032	.9032	.9516
	3	.9355	1.0645	.9516	.9194	.8710
	$\bar{x}$	.9677	.9839	.9409	.9247	.9140

APPENDIX D

RAW DATA--FEMALE

SUBJECT	TRIAL	POS 1	POS 2	POS 3	POS 4	POS 5
1	1	1.0161	.9839	.9355	1.0161	1.0645
	2	.9677	1.0645	.9194	.9355	1.0161
	3	.9677	1.0806	--	1.0645	.9839
	$\bar{x}$	.9839	1.0430	.9274	1.0054	1.0215
2	1	1.3266	1.2097	1.2581	1.2258	1.2258
	2	1.3387	1.1290	1.2097	1.2419	1.2419
	3	1.2419	1.1774	1.2581	1.1774	1.1452
	$\bar{x}$	1.3011	1.1720	1.2419	1.2151	1.2043
3	1	1.0323	.9516	.9839	.9516	.9355
	2	.9355	.9839	.9516	.9516	.9677
	3	1.0484	.9516	.9677	.9677	1.0323
	$\bar{x}$	1.0054	.9624	.9677	.9570	.9785
4	1	1.3710	1.0968	1.0806	1.0323	1.0645
	2	1.1129	1.0645	1.0806	1.0000	1.0968
	3	1.3548	1.0645	1.0645	1.1129	1.0645
	$\bar{x}$	1.2796	1.0753	1.0753	1.0484	1.0753
5	1	1.0323	.9839	1.0161	1.0000	.9839
	2	.9839	.9516	.9516	.9677	.9516
	3	.9194	.9839	.9677	1.0323	.9839
	$\bar{x}$	.9785	.9731	.9785	1.0000	.9731
6	1	1.0645	.9677	1.0000	.9839	1.0161
	2	1.0645	.9516	.9839	1.0000	1.0323
	3	1.0484	.9516	1.0000	.9355	1.0484
	$\bar{x}$	1.0591	.9570	.9946	.9731	1.0323
7	1	1.0000	1.0968	1.0968	1.0645	1.1129
	2	1.1452	1.0161	1.1129	1.0484	1.0645
	3	1.1774	1.1129	1.0807	1.2097	1.1613
	$\bar{x}$	1.1075	1.0753	1.1129	1.1075	1.1129
8	1	.9839	1.0323	.9839	.9194	.9677
	2	.9516	.9516	.9355	1.0000	1.0161
	3	.9355	.9516	.9194	.9839	.8065
	$\bar{x}$	.9570	.9785	.9462	.9677	.9301

SUBJECT	TRIAL	POS 1	POS 2	POS 3	POS 4	POS 5
9	1	.9355	1.0161	.9194	.9839	.9677
	2	.9677	.9839	.9355	1.1129	1.0968
	3	.9516	.9516	.9677	1.0968	1.0645
	$\bar{x}$	:9516	.9839	.9409	1.0645	1.0430
10	1	1.0645	.9032	.9677	.9677	.9677
	2	.9677	.9355	.9032	.9355	.9839
	3	1.0968	.9677	1.0000	.8710	1.0161
	$\bar{x}$	1.0430	.9355	.9570	.9247	.9892

APPENDIX E

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENT

X	Y
76	76
60	60
65	64
64	65
62	61
61	61
60	60
64	64
55	53
60	60
63	63
64	64
69	67
66	66
68	68
61	61
63	63
63	63
64	64
62	62
$\Sigma X = 1270$	$\Sigma Y = 1265$

$$r = \frac{N\Sigma XY - (\Sigma X)(\Sigma Y)}{\sqrt{\left[N(\Sigma X^2) - (\Sigma X)^2\right]\left[N(\Sigma Y^2) - (\Sigma Y)^2\right]}} = .92$$

APPENDIX F

RESULTS OF SURVEY CONDUCTED UPON COMPLETION OF SUBJECTS FILMING SESSIONS

QUESTION 1	Was Quickest	Was Not Quickest
Which of the five ready positions felt quickest?		
Position 3--25%	2	3
Position 4--55%	3	8
Position 5--20%	1	3

QUESTION 2	Was Slowest	Was Not Slowest
Which of the five ready positions felt slowest?		
Position 1--65%	5	8
Position 2--10%	0	2
Position 4--10%	0	2
Position 5--15%	0	3

QUESTION 3	Was Quickest	Was Not Quickest
Which of the five ready positions most resembled your own?		
Position 3--25%	2	3
Position 4--55%	2	9
Position 5--20%	1	3

APPENDIX G

INFORMED CONSENT FORM

In this study, you will perform five different ready positions for the return of service which will be filmed. Each position will be explained and demonstrated. You will then be asked to practice the position until you feel comfortable with it. Any questions concerning the procedures or positions will be answered. It is important that you try to do the very best you can when performing the positions.

Films of subjects will be property of Robert D. Shacklett and shall be used for experimental use and presentations only.

I, do hereby give consent to Robert D. Shacklett and the University of Montana to use myself as a subject for thesis data gathering.

_____ SUBJECT

_____ PARENT (If under 18)

_____ DATE