



The relationship of reaction time and movement time to racquetball success
by Gregory Dale Olson

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE
in Physical Education

Montana State University

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Abstract:

A study was conducted to compare racquetball success with reaction time (RT), movement time (MT), and the composite of the two—total time (TT). These variables were compared between two groups of eleven players. The groups were established according to the results of a double elimination tournament. The top eleven finishers formed the high ability group, while the bottom eleven players formed the low ability group. Total time and RT data were collected while speed of movement was computed. t-tests and F-ratios were used to determine if any significant difference existed between the means and/or variability of the two groups in any of the three variables. The findings were as follows:

1. The mean TT was significantly lower in the high ability group as compared with the low ability group.
2. The mean RT was significantly lower in the high ability group as compared with the low ability group.
3. The mean MT and the MT variability were not significantly different between the high ability group and the low ability group.
4. Reaction time variability was significantly less in the high ability group as compared with the low ability group.

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ABSTRACT

A study was conducted to compare racquetball success with reaction time (RT), movement time (MT), and the composite of the two--total time (TT). These variables were compared between two groups of eleven players. The groups were established according to the results of a double elimination tournament. The top eleven finishers formed the high ability group, while the bottom eleven players formed the low ability group. Total time and RT data were collected while speed of movement was computed. t-tests and F-ratios were used to determine if any significant difference existed between the means and/or variability of the two groups in any of the three variables. The findings were as follows:

1. The mean TT was significantly lower in the high ability group as compared with the low ability group.
2. The mean RT was significantly lower in the high ability group as compared with the low ability group.
3. The mean MT and the MT variability were not significantly different between the high ability group and the low ability group.
4. Reaction time variability was significantly less in the high ability group as compared with the low ability group.

Chapter 1

INTRODUCTION

Reaction time, speed of movement time, and the composite of the two--total time, have been of interest in the field of Physical Education since before the turn of the century. With the development of better instrumentation, scientists have been able to make more precise measures of reaction and speed of movement times. Using advanced electronics, we can measure in milliseconds. Using advanced technology, scientists can better explore the relationships of reaction and movement times and their effects on athletic performance. In the following study, the researcher will explore the areas of reaction time and speed of movement time.

Statement of the Problem

The purpose of this investigation was to examine the relationships among reaction time, speed of movement time, the total time and success in racquetball. Selected subjects consisted of twenty-two male racquetball players. Specific problems for exploration were:

1. to identify the relationship between reaction time and success in racquetball,

2. to identify the relationship between speed of movement and success in racquetball,
3. to identify the relationship between total time and success in racquetball,
4. to identify the relationship between consistency and success in racquetball,
5. to identify which of the three variables, total time, reaction time, and speed of movement, is of the greatest importance in relationship to success in racquetball,
6. to identify and describe the characteristics of total time, reaction time, and movement time, and the relationships which may exist between them.

Hypothesis

It was hypothesized that total time, reaction time, and movement time have no significant effect on racquetball success.

Alternate. It was hypothesized that total time, reaction time, and movement time do have significant effect on racquetball success.

Delimitations

The investigation was limited to twenty-two male racquetball players between the ages of 19 and 45. All of the subjects met the eligibility requirements of the Montana State University intramural department, which limited racquetball participation to university students and faculty. Subjects were playing racquetball and were participants in a double elimination tournament at the time of the study. Subjects were given no motivation to attempt to increase their reaction time or movement time speeds.

Limitations

Each subject was tested at a random time during the day. There was no attempt to control variations in eating and sleeping habits or fatigue. Secondly, various limbs and sections of limbs have different reaction times and movement times. The specific combination tested was an expeditious clapping motion with the hands at the level of the illiactic crest.

Another limiting factor may be that the H-O reaction test was a simple task and may not compare to the complex visual stimuli of a racquetball game. Furthermore, speed of movement is changeable according to the direction

of force applied to the limb. Only one specific direction was tested--the direction of the hands moving horizontally toward one another. This direction was chosen since it stimulates a motion commonly made in a racquetball game.

Reaction time is faster when subjects are given a simple stimulus rather than a complex stimulus. Uncontrolled factors which may have limited racquetball success included innate coordination, amount of practice, psychological and physical condition.

The assumption was made that the simple reaction and movement time in the experiment represented the characteristic reaction and movement time of the individual, and could be compared to other subjects performing the same task.

Definitions

The following terms as used in this study are confined to the following definitions:

Chase stick - a 3/4" dowel, 36" long on which the subject placed his hand at the beginning of each trial. The purpose of the chase stick was to keep the subject's hands traveling in a horizontal plane.

Foreperiod. The time elapsed between the "ready" signal, given by the subject, and the time of the throwing of the switch. The time was counted from a random number table between zero and nine.

Reaction time. (RT) The time elapsed in milliseconds between the visual stimulus and the time at which the circuit was broken, i.e., first movement.

Speed of movement. (MT) The time in milliseconds which elapsed between the subject's (S) movement and the catch of the Nelson Reaction Timer.

Chapter 2

REVIEW OF RELATED LITERATURE

Many studies have been completed that deal with RT, MT, and TT which are relevant to the following study. Studies of this nature deal with a variety of subjects. Therefore, a division was made into the following categories:

1. Practice and learning,
2. Psychological and Motivational conditions affecting RT and MT,
3. Effects of gender and age upon RT and MT,
4. Physiological effects,
5. Relationship of RT and MT to athletic success.

The Memory Drum Theory

The Memory Drum Theory of Neuromotor Reaction, according to Christina (9), suggests that the redundant motor elements of a fast, complicated, learned movement are governed by a non-conscious motor memory mechanism. The mechanism controls and channels the flow of impulses into the appropriate neuromotor coordination centers and nerves --thus affecting movement in a somewhat automated fashion. Increased RT and MT would result when one thought more

about a movement. In the same manner, RT and MT would increase because of an interference with the memory mechanism.

Practice and Learning

Researchers have shown, that the learning effect in RT trials takes place within the first five trials of a task (9,16,28). Henry (16) showed that RT and movement task learning occurs very rapidly and stated that reaction task learning occurs at a quicker pace than does movement task learning.

Luachei (24) approximated that forty milliseconds of RT interval was necessary for the subcortical and spinal motor processing required for coordination of the normal reaction movement. One hundred and twenty milliseconds were needed for a full RT response to a visual stimulus. Henry (16), Clark (12), and Smith (33) found RT and MT to be independent and uncorrelated.

Norrie (29) found practice does not appreciably affect the amount of variability in RT or MT within the individual, except for RT in the first five trials. Reaction time during the first five trials was variable because of a learning factor.

Aiken and Lichtenstein (1) found that the mean RT to a visual stimuli would increase proportionately with the length of foreperiod--the foreperiod time ranging from one to ten seconds.

Botwinick (5) found that the shorter the foreperiod, the faster the RT under six different auditory stimulus intensities.

Over a four day period Carson (7) found that RT response consistency was high in thirty right-handed college males. The reliability coefficients for four different RT measures over four days were .797, .830, .780, and .793, respectively.

Psychological and Motivational Conditions Affecting RT and MT

Nash (26), studying the effects of manifest and induced anxiety, found that under stress induced by electrical shock, simple RT is slower than under no stress. However, he did find that there was no relationship between the level of anxiety as measured by the Taylor Manifest Anxiety Scale, and simple RT. In other words, simple RT was not affected by the level of manifest anxiety according to the Taylor Manifest Anxiety Scale.

Henry (15) showed that both RT and MT can be improved by motivation. All of the ninety-three volunteers from a men's physical education class in elementary gymnastics and tumbling improved significantly ($p < .05$) in RT, and most of them improved in MT regardless of the motivating stimuli they received. The five groups of stimuli were:

1. No motivating stimulus,
2. motivated by a dim light,
3. motivated by a bright light,
4. motivated by a bright light plus shock,
5. motivated by sound.

Effects of Gender and Age Upon Reaction Time and Movement Time

Hodgkins (18) in studying the difference of RT and MT between males and females found males were faster than females in both RT and MT. The speed of both RT and MT increased until early adulthood (19 years old) and then decreased, according to Hodgkins. The peak speed in males is maintained longer in life than in females.

Botwinick (5) found the responses of the elderly (sixty-five to eighty-one years of age) were much less variable than younger groups (eighteen to thirty-two years

of age). There were twenty-nine subjects tested in the older group, and thirty-four subjects tested in the young group. Furthermore, he found that the slowing of mean TT was not related to motivation. He did find that the slowing may be related to a state of preparedness on the part of the S to respond.

Evans (13) in a fifty year longitudinal study found that simple-sensory reaction to auditory stimulus in an undistracted condition did not increase or decrease significantly over a fifty year period. He did find that if irregular or intermittent types of distractions were made, simple sensory reaction would increase significantly. Evans stated that speed of response is directly related to the difficulty of the task.

Physiological Effects

Henry (15) found that the strength--mass ratio of a limb seemed to be unrelated to limb speed.

Meyers (25) determined that strenuous physical exercise had no discernable effect on simple finger and foot RT. He stated that there was no apparent relationship between RT and the sum of the recovery pulse counts following the exercise.

Tweit (37), in his study of the effects of a training program on individuals of low fitness, found that total body RT was significantly ($p < .01$) improved by participation in a strenuous physical training program. However, Rarick (2) found that speed of muscular performance cannot be increased appreciably in highly skilled individuals.

Phillips (31) found that arm exercises produced no statistically significant advantage in MT. He also found that warm-up exercises do not influence RT.

Schmidt (35), in studying the effects of positional tensioning and stretching on RT and MT, found that stretching had no effect on either RT or MT. Furthermore, he found that MT was not affected by positional tensioning, but RT was. According to Schmidt (35), RT decreased progressively with increased positional tensioning.

Smith (33) found that during a state with tensioned muscles, the S produced a four percent faster MT and a seven percent faster RT, as compared with having the arm in a more relaxed condition. However, the increases were statistically ($p < .05$) insignificant between conditions of relaxation, tension, and stretch.

Clark (10) concluded from his study of preliminary muscular tension on RT, that increased muscular tension in the form of preparatory set, resulted in a faster RT.

Smith (34) found the arm to be four percent faster than the leg in a forward motion, but that the direction of movement had no effect upon RT of the arm. In addition, he stated that speed was clearly specific to the limb.

Relationship of Reaction Time and Movement Time to Athletic Success

Studies done previously on the relationship of RT and MT to athletic success are conflicting. Keller (19), in his study of the relationship of quickness to success in athletics stated, "There is a positive relationship between the ability to move fast and success in athletic activities." He also states, "The relationship for quickness is not the same for all sports." (20, p. 154)

The variability in RT's of sportsmen, according to Knapp (22), is significantly less ($p < .01$) than the variability in the RT's of research students. Knapp (22) also stated that top class racquet-game players, between the ages of twenty and thirty, have significantly faster RT's than those of a sample population of twenty to thirty-year old students.

Patrick (30), in studying basketball players came to the conclusion that, "Boys with the best reaction time were not only the best basketball players as determined by subjective rating, but were better in sports where quick reaction was a factor." (31, p. 68) He goes on to say that potential basketball players have quicker reaction time to visual stimuli than boys with restricted basketball potential.

Waechter (38), in his study of MT of selected groups of athletes and non-athletes, found that there was no significant difference in MT between non-athletes and athletes. All groups had a mean TT of one hundred and forty-four milliseconds.

The above studies all deal with variables which may affect RT and MT. Generally, it can be stated that there are four categories of variables that affect RT and MT.

They are:

1. those variables unrelated to RT and MT,
2. those variables positively affecting RT and MT,
3. those variables negatively affecting RT and MT,
4. those variables which are conflicting.

Those variables unrelated to RT and MT were practice, the strength-mass ratio of limbs, warm-ups, anxiety

(only RT), direction of movement, and tests being conducted on different days. Furthermore, it was found that RT and MT were unrelated.

Those variables positively related to RT and MT were motivation factors, muscular tension, and shortening the foreperiod. Variability seems to decrease with age and athletic ability.

Those variables negative affecting RT and MT seem to be thinking about the task, stress, complexity of the task, age, and lengthening the foreperiod time.

Conclusions regarding the effects of selected physiological states on RT were conflicting.

Chapter 3

METHODS AND PROCEDURES

The following study attempted to measure the relationship of three variables--RT, MT, TT--to success in the game of racquetball.

Racquetball Success

Success in racquetball was measured by the use of a double elimination racquetball tournament. Rules governing the elimination or progression of S's were only that the player win or lose two out of three games. International Racquetball Association rules were used.

Instrumentation

The following instruments and machines were used and designed for the accumulation of RT, MT and TT data on the S's.

A wide range oscillator (Model 200 cd, Hewlett-Packard) with a variable frequency output from 0 to 65 x 10k. An electronic counter (Hewlett-Packard 532/B) which counted the number of frequencies put out by the oscillator. The electronic counter counted up to six digits. A Nelson reaction timer, 30" long, designed by Fred B. Nelson. Gravity was a constant (32 ft./sec./sec.) as the timer was

released from a magnet and dropped to the floor. The reading obtained from the timing stick was calibrated in milliseconds and was defined as TT. (Nelson reaction timer, Model RT-2) A variable direct current power supply (California Computer Products, Model 30-500) was set for nine volts direct current. A H-O reaction and speed of movement instrument designed by Dr. Ralph Hight and the researcher made it possible to put all of the aforementioned equipment into one functioning unit. A photograph may be seen in Figure 1. A black box, 6" x 6" x 4", housed a switch which controlled the entire apparatus. An electrical diagram is shown in Figure 2.

Operation and Control of Reaction Instrument

The variable frequency oscillator was set at ten thousand frequencies per second. The oscillator and counter were checked for accuracy by placing the dial on the "one second" setting. The electronic counter counted the number of frequencies for one second. Any slight adjustment of the frequency oscillator was therefore possible.

The dial of the electronic counter was placed in the open gate position which allowed the counter to count

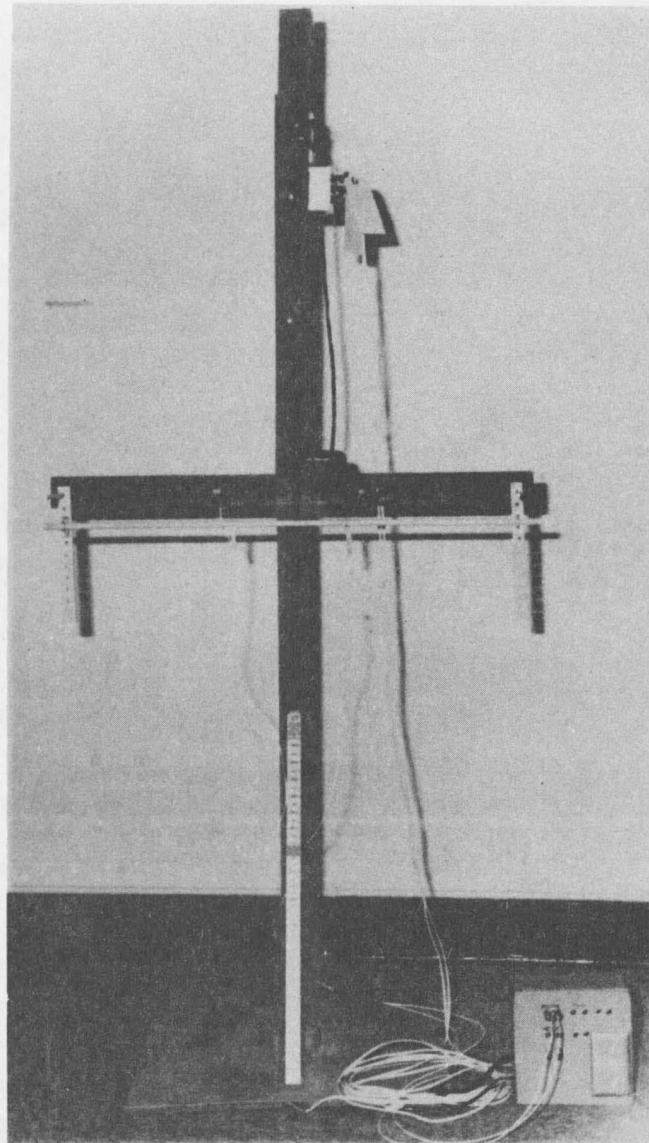


Figure 1. H-O Reaction and Speed of Movement Instrument

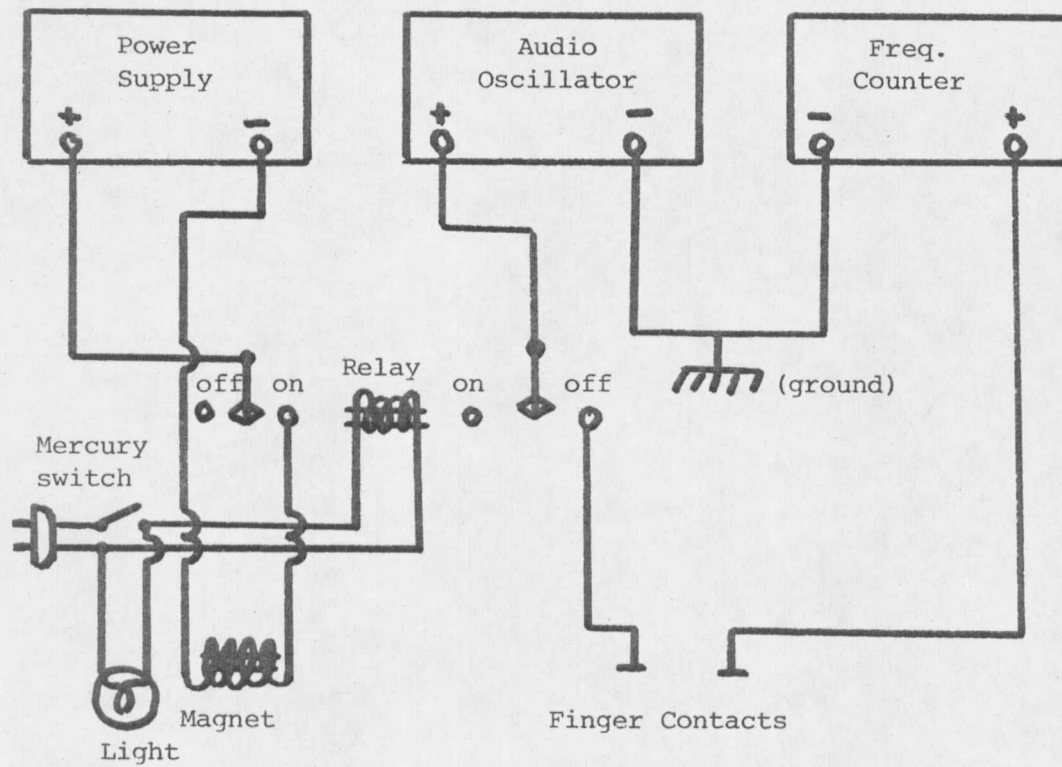


Figure 2. An electrical schematic

continually from zero to infinite seconds. With the switch in the up position, the electronic counter would read zero.

The S was instructed to hold his hands and fingers flat against the positive and negative poles, thus completing the circuit, while resting his fifth digit (little finger) against the chase stick. The S's hands were eight inches apart.

The control box panel switch was put in the up position which closed the circuit to a lightbulb, and turned the lightbulb on. The power from the variable power supply, which was set at nine volts, ran through a magnet, which created a magnetic force. The Nelson reaction timer was attached to the magnet with the top of the reaction timer flush with the top of the magnet.

By throwing the switch to the down position, the circuit to the lightbulb was opened which shut the bulb off. The electricity to the magnet was cut which turned the magnet off and released the Nelson reaction time stick. The circuit (low amperage and voltage) was complete through the S's body, the oscillator, and the electric counter as long as the S had his hands connecting the positive and negative poles. The counter counted ten thousand frequencies for every second. As the S saw the stick

drop and tried to catch it, his first movement was made away from the poles which broke the circuit and the electronic counter stopped counting. The frequencies which elapsed between the throwing of the switch (or the first falling of the stick) and the broken circuit (or the first movement of the S) was recorded on the electronic counter and was called the RT.

As the magnet's power was cut, the stick began to fall at a constant speed of 32 feet per second per second. The falling stock provided the stimulus. S reacted to the stimulus by closing his hands together in a singular clapping motion catching the stick between them. A reading was taken in relation to a pencil mark in the center of the S's index finger and the calibration on the Nelson reaction timer. This reading was the TT.

Since the stick was calibrated to show the elapsed time between the drop and the catch, the researcher had the TT measured, which included RT and MT. To arrive at the MT, a subtraction was made of the RT from the TT.

Experimental Procedure

The S was given an explanation of the test he was to be given. The equipment was then adjusted to the S's

body. The height of the cross-bar was adjusted to be on the same horizontal plane as the highest section of the S's illiactic crest. The purpose of adjusting the cross-bar was to put each S's movement on the same plane in relationship to his own body.

The S was instructed on how to read the RT stick. An ink mark was placed on his left index finger as a reference point from which to read the Nelson RT stick. He was also instructed on how to place the stick on the magnet in order that a true reading would not be hindered by improper placement. The S placed the RT stick in position and took the proper stance--feet about shoulder width apart, elbows at the sides, eyes on the baseline of the stock, and the back straight. With the S's hands now touching the plates, a quick circuit check was made confirming the cycles per second (10,000).

When a "ready" verbal signal was heard from the S, the researcher voiced, "Ready, here we go." The researcher started to count the foreperiod silently from zero to nine. A series of foreperiods was previously selected from a table of random numbers. When the switch was thrown, the first stimulus would occur and all the above mentioned readings could then be taken.

Seven practice trials were given. The S was given twenty additional trials of the test. He was asked not to anticipate. If he did so, or felt he was not ready, he was instructed to inform the researcher, who would then delete the trial of the test. A full twenty correct trials were executed.

Reliability

To test the reliability of the testing procedure, two tests were given to each of 10 S's two weeks apart. The coefficients of reliability were found to be .81166, .54894, and .59194 for the TT, RT, and MT tests which corresponds with confidence levels of .01, .10, and .10, respectively.

Statistical Analysis of Data

The twenty-two S's were divided into two groups of eleven. The groups were established according to each individual's placement in the double elimination tournament. The high ability group consisted of the first eleven place winners, while the low ability group consisted of the bottom eleven players. When a tie occurred, the S's placement was determined by his win/loss record. The S with the greater number of wins before a loss would take

presidence over a person who lost earlier in the double elimination grid. In the case of a duplicate win/loss record, the S challenging the opponent that placed highest on the double elimination grid was chosen for the higher ranking.

TT, RT, and MT were measured using the H-O reaction and speed of movement timer. The data was then processed by a Sigma VII Computer at the Montana State University Computing Center to determine the mean, standard deviation, and variance of each S's twenty scores in each of the three parameters studied, and the mean, standard deviation and variance for each of the two groups. T-tests were used to determine whether the mean TT, RT, or MT were significantly different between the high ability group and the low ability group. F-ratios were used to compare the variability of the two groups.

Chapter 4

RESULTS

The results of the double elimination tournament and the data collected from TT, RT, and MT tests are presented in the following tables.

Table I presents the rank listings of the S's from the double elimination tournament and the means and standard deviations for TT, RT, and MT for each subject.

The range of the mean TT for each individual TT of the high ability group was 48.00 milliseconds with an upper limit of 218.00 milliseconds and lower limit of 170.00 milliseconds. The range of the mean TT for each individual in the low ability group was 71.00 milliseconds with an upper limit of 249.50 milliseconds and a lower limit of 178.50 milliseconds.

The range of the mean RT for each individual of the high ability group was 32.81 milliseconds with an upper limit of 160.16 milliseconds and a lower limit of 131.33 milliseconds. The range of the mean for each individual in the low ability group was 45.77 milliseconds with an upper limit of 180.61 milliseconds and a lower limit of 134.84 milliseconds.

Table 1. Rank listing, means, standard deviations of each S. Times in milliseconds

		TT		RT		MT	
Rank		$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
Group 1	1 MC	206.50	24.551	147.05	13.210	59.45	27.879
	2 HA	189.00	14.457	133.78	12.961	55.22	19.416
	3 RJ	170.00	16.125	143.64	15.823	26.36	22.591
	4 JTa	208.00	16.000	147.44	20.314	60.56	25.858
	5 BJ	173.50	23.722	155.97	18.601	17.54	30.146
	6 JN	188.00	12.884	139.32	12.012	48.69	17.615
	7 MRu	197.00	17.917	146.03	10.737	50.97	20.888
	8 SD	218.00	16.912	160.16	13.193	57.84	21.449
	9 TH	173.50	23.722	131.33	20.143	42.18	31.121
	10 JCy	187.50	20.218	143.51	16.661	43.99	26.198
	11 TH	217.00	16.462	164.14	17.817	52.87	24.258
Group 2	12 BE	211.50	14.239	173.10	15.179	38.41	20.812
	13 JB	212.50	24.469	180.61	28.709	31.89	37.722
	14 AL	212.00	17.493	173.93	20.772	38.07	27.156
	15 RS	178.50	12.757	138.03	12.353	40.47	17.758
	16 JCo	193.50	20.803	156.43	16.635	37.07	26.636
	17 NK	249.50	30.245	160.40	16.842	89.11	34.617
	18 BW	199.00	17.578	166.38	16.978	32.62	24.439
	19 TB	181.05	30.069	134.84	12.772	46.21	32.669
	20 MRi	214.25	18.793	156.21	18.514	58.05	26.381
	21 MP	200.00	18.708	148.60	15.584	51.41	24.349
	22 BB	212.90	16.961	149.80	10.557	63.10	19.978

The range of the mean MT for each individual in the high ability group was 43.02 milliseconds with an upper limit of 60.56 milliseconds and a lower limit of 17.54 milliseconds. The range of the mean MT for each individual in the low ability group was 57.22 milliseconds with an upper limit of 89.11 milliseconds and a lower limit of 31.89 milliseconds.

Comparison of Means

Table II presents means, variances, t-tests, and F-ratios of the high ability group and the low ability group. The mean TT's for the two groups were compared. The mean TT of the high ability group and low ability group were 193.65295 milliseconds and 206.20369 milliseconds, respectively. The t score of 4.98213 for TT was above the $p < .01$ and $p < .001$ level of significance. The high ability group had a significantly faster mean TT than the low ability group.

The mean RT's for the two groups were compared. The mean RT's of the high ability group and low ability group was 146.54480 milliseconds and 157.64825 milliseconds, respectively. The t score for RT was 5.72147 which was significant at the $p < .05$ level. The RT score also

Table 2. Number, means, variance, F-ratio, and t-test of Group 1 and Group 2. Means in milliseconds

		<u>Total Time</u>			F-ratio	t-test
	N	$\bar{X}$	Variance			
Group 1	219	193.65295	623.29810		1.21587	4.98213***
Group 2	216	206.20369	757.85107			
		<u>Reaction Time</u>			F-ratio	t-test
	N	$\bar{X}$	Variance			
Group 1	219	146.54480	351.68799		1.33137*	5.72147***
Group 2	216	157.64825	468.22778			
		<u>Movement Time</u>			F-ratio	t-test
	N	$\bar{X}$	Variance			
Group 1	219	46.09407	330.87842		1.00655	.97729
Group 2	216	44.38658	333.04492			

t-test - significance .05 is T 1.960
 .01 is T 2.576
 .001 is T 3.291

F-ratio - significance .05 is F 1.26
 .01 is F 1.39

* signifies confidence level at .05
 ** signifies confidence level at .01
 *** signifies confidence level at .001

indicated that t is above $p < .01$ and $p < .001$ level of significance. The high ability group had a significantly faster RT than the low ability group.

The mean MT's for the two groups were compared. The mean MT's of the high ability group and the low ability group were 46.09407 milliseconds and 44.38657 milliseconds, respectively. The t score for MT was .97729 which fell below the required significance at the .05 level. The high ability group did not have a significantly faster MT than the low ability group. The data indicated that the low ability group had a faster mean MT than the high ability group.

From the data obtained, the null hypothesis was rejected for TT and RT, while being accepted for MT. Thus, the t -test indicates that in comparing the high ability group's mean TT and mean RT to the low ability group's mean TT and mean RT, the high ability group had a significantly faster mean TT and mean RT than the low ability group.

Comparison of Variability

The F-ratio, which compared the variances of the high ability group and the low ability group was 1.21587.

and 1.00655, respectively. These scores fell below the needed F of 1.26 and were, therefore, not significant ($p < .05$). The F-ratio indicates that both TT and MT, as analyzed by the F-ratio had a non-significant variability between the high ability group as compared to the low ability group.

The F-test score for RT was $F=1.33137$, which was above the needed F of 1.26 and, therefore, was significant at the $p < .05$ level of confidence. The data indicates that the variability of the high ability group's mean RT scores as compared to the variability of the low ability group's mean RT scores was significant. The high ability group was significantly less variable than the low ability group.

The data obtained from the tabulated R-ratio indicates that the null hypothesis which stated that there would be no significant difference between the variables of TT, RT, and MT of the two groups would be rejected for TT and MT, while accepted for RT. Thus, the RT variability as analyzed by the F-ratio was significant. The high ability group was significantly less variable than the low ability group in RT but not TT or MT.

Chapter 5

DISCUSSION

The null hypothesis which stated that there would be no significant difference in mean TT, RT, and MT between high ability and low ability racquetball players was accepted for MT while being rejected for TT and RT as analyzed by the t-test. Use of the F-ratio indicated that the null hypothesis would be accepted for TT and MT while rejected for RT. The experimenter would speculate that the playing ability of the high ability group was enhanced by the player's speed of internal reaction (TT was the addition of RT and MT).

It is, therefore, speculated that TT as analyzed by the t-test was significant because of the method by which it was derived. That is, TT may be significant because of RT and not MT. This relationship indirectly supports the Memory Drum Theory of neuromuscular reaction. Once the internal mechanisms for reacting to a stimulus involved in racquetball has been developed, RT becomes faster. This speed may be due to the more efficient flow of impulses into the appropriate neuromotor centers and nerves developed through repetition. The Motor Drum Theory of Neuromotor Reaction, according to Christina (9), seems

to be supported by this study for RT in racquetball. Increased RT could have been caused by a S's thinking about a movement. Consequently, cortical involvement may have caused an interference with the memory mechanism. This interference may have slowed RT in racquetball and could affect racquetball success. Perhaps the low ability group at the time that this study was conducted had not developed the same degree of neuromotor efficiency as the high ability group. The efficiency could be due either to the S's experience or exposure in the game of racquetball, or due to lower levels of neuromuscular coordination. There may also have been interference from undetected neuromuscular disorders.

An interesting phenomenon which was indicated by the mean MT appeared between the two groups. The low ability group appeared to have faster mean MT than the high ability group by approximately two milliseconds. Although this is not a significant difference, it may indicate that at least in racquetball playing ability, a S's MT is not as influential as RT.

The significance of RT in the high ability group seems to indicate that RT is more influential in determining racquetball success. The faster mean MT in the low

ability group seems to indicate that those S's may have been moving more rapidly, but with less consistency. This factor may affect the racquetball success of S's in the low ability group. Differences between the high ability group and the low ability group as analyzed by the F-ratio in RT were significant ($p < .05$). The experimenter would speculate that the consistency, as well as the speed of RT, are both important. The high ability group is much more consistent than the low ability group in RT. Under these circumstances, the high ability group would be able to react to situations as they developed with greater speed and consistency than the low ability group.

It seems that of the three variables studied, a S's racquetball success may be most influenced by his RT. However, as the data indicated, TT as well as RT are both significant to racquetball success in the high ability group.

The results of this study in relationship to previous studies was found to be conflicting in some areas. Henry (16), Clark (11), and Smith (33) found RT and MT to be independent and uncorrelated. This study shows RT and MT to be significantly correlated ($p < .01$). The r was .69954.

Luachei (24) approximated that forty milliseconds was necessary for subcortical and spinal motor processing required for coordination of normal RT. One hundred and twenty milliseconds were needed for a full RT response to a visual stimuli. This study found the lowest mean RT among twenty-two S's to be 131.33 milliseconds.

Chapter 6

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

A study was conducted to compare racquetball success with RT, MT, and the composite of the two--TT. These variables were compared between two groups of eleven players. The groups were established according to the results of a double elimination tournament. The top eleven finishers formed the high ability group, while the bottom eleven players formed the low ability group. Total time and RT data were collected while speed of movement was computed. t-tests and F-ratios were used to determine if any significant difference existed between the means and/or variability of the two groups in any of the three variables. The findings were as follows:

1. The mean TT was significantly lower in the high ability group as compared with the low ability group.
2. The mean RT was significantly lower in the high ability group as compared with the low ability group.

3. The mean MT and the MT variability were not significantly different between the high ability group and the low ability group.
4. Reaction time variability was significantly less in the high ability group as compared with the low ability group.

Conclusions

1. Of the three variables studied, success in racquetball seems to be more dependent upon reaction time than movement time or total time.
2. Movement time does not seem to have an effect upon success in racquetball.
3. The consistency of reaction time and not total time or movement time seems to have an effect upon success in racquetball.
4. Total time seems to have an effect upon success in racquetball, although this may be due to the influence of reaction time.

Recommendations

The following are recommendations for future studies:

1. There should be further studies of the importance of reaction time in relation to sports of all types.
2. There should be further studies to see if reaction time can be decreased through practice or repetition.
3. There should be further studies to determine if reaction time can be used as an athletic predictor.
4. There should be further studies to see if RT can be speeded through training or learning.
5. There should be further studies to find the relationship of RT in one part of the body compared with RT in another part of the body

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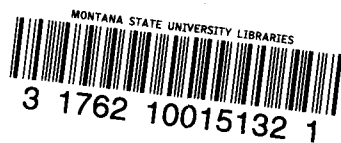
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