THE EFFECTS OF DYNAMIC AND STATIC STRENGTH TRAINING ON SPEED OF MOVEMENT

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Arlan F. Barber

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THE EFFECTS OF DYNAMIC AND STATIC STRENGTH TRAINING ON SPEED OF MOVEMENT

By

Arlan F. Barber

AN ABSTRACT

Submitted to the College of Education of Michigan State University of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

Department of Health, Physical Education, and Recreation

1963

Approved Wayne A. Van Huss

ABSTRACT

THE EFFECTS OF DYNAMIC AND STATIC STRENGTH TRAINING ON SPEED OF MOVEMENT

by Arlan F. Barber

Statement of the Problem

To determine the effect of static and dynamic strength training methods on the speed of a dominant arm movement.

Methodology

Sixteen undergraduate service course students served as subjects. Four students were placed in each of the following four groups: control group, repetition group, isotonic group and the isometric group. The criterion for matching subjects was movement time. The subjects were required to move their dominant arm laterally twenty inches from right to left. The arm was extended throughout the entire movement, the palm of the hand held in a position facing the electric-eye beam.

The subjects were trained in a seating position identical to the position they assumed when being tested. The four groups were required to train three times per week (Monday, Wednesday, Friday) for five weeks.

Group A, the control group, was tested initially and finally. These subjects continued their normal daily routine and did not become involved in any training programs that might effect their upper extremities.

Group B, the repetition group, was required to perform the designed lateral movement from right to left, with

maximum effort, twenty-five times three days per week for five weeks. All training was without load.

Group C, the isotonic group, trained within the twenty-inch testing range. The procedure included a series of three trials with a three minute rest period separating the trials. Each individual trial consisted of six successive maximum overload exercises. The equipment used consisted of a handle with an attached rope extending through a pulley to a fixture capable of securing the necessary weights.

Group D, the isometric group, trained with five maximum contractions held for six seconds each. The subjects were given a ten second rest between each contraction. The point of contraction was a post, one inch in diameter, extending perpendicularly from a table so fixed as to assimulate point zero of the testing range. The contraction was held at a ninety degree angle from the body.

The testing apparatus consisted of a stimulus unit, a response unit, and a recording unit. Movement time was recorded in 1/1000 of a second and reaction time was recorded in 1/100 of a second.

The differences between the group means were compared using the Duncan Multiple Range test. The relationship between reaction time and movement time was determined using rank-order correlations.

Conclusions

1. Movement time was not significantly improved through repetition, isotonic or isometric training programs over a five week period.

2. Reaction time was not significantly improved over a five week period through repetition, isotonic, or isometric training procedures.

3. Reaction time and movement time were not significantly related. (Initial r = -.282, final r = .239.)

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TABLE OF CONTENTS

LIST OF TABLES

TABLE OF ILLUSTRATIONS

CHAPTER I

INTRODUCTION

The speed with which man can move is often a limiting factor in performance of athletic events, industrial tasks, and military requirements. Man is continually in need of further information regarding the specificity of training for the improvement of speed.

How do we improve the speed of motion? Tradition, observation, and personal opinion have, in the past, been responsible for our training methods. There is a pressing need for sound research from which we can derive improved training techniques. It is hoped this study will contribute to our knowledge regarding the specific training techniques for improved speed of movement.

There have been several studies concerning the problem of reaction time and speed of motion. Many such studies deal with varying types of stimuli for the purpose of cross-checking or to study reinforcement of motivation. In the past few years, Henry[7] has conducted a variety of studies in this particular area.

The primary concern of this study was to assess several methods for their effect on speed of movement. A secondary issue was to correlate reaction time and speed of motion.

Statement of Problem

To compare the effects of selected training programs upon the speed of movement.

Purpose of Study

It is the author's opinion that methods exist that are capable of increasing the speed of motion. If the results of this study are significant, it may be possible to apply this information to the development of major muscle groups that are greatly concerned with the speed of motion.

It was said at one time that no man could ever run a mile in less than four minutes. Today we realize how absurd this statement was. Because of research and implementation of training techniques, man's ultimate potential is more of a question today than it has ever been. Likewise, it has been taught that a man is born with or without fast contracting muscles. Therefore, few coaches, even today, attempt to train for increased speed of movement. This study might lend further information to this field of endeavor.

Need for the Study

There are very few athletic events or training techniques that are not highly dependent upon the development of speed. Examples of such events are baseball, tennis, badminton, handball, paddleball, football, and a wide variety of other sports. It is obvious that better understanding of this characteristic is needed to permit intelligent application of appropriate training techniques.

Definition of Terms

Reaction time. The time interval between initiation of the stimulus and the start of the muscular response.

Movement time. The difference between total time and reaction time. In this study it is that time between the start of movement and the breaking of the electric eye beam twenty inches away.

Stimulus. A buzzer creating a sound of constant, undetermined intensity at irregular intervals.

Limitations of the Study.

The testing procedures were limited to movement of the dominant hand and arm only, and not to the total body. This measure may not be as representative of movement time as would other types of movements. All subjects were not controlled but the subjects were told to continue their normal routine.

Motivation could not be controlled. Testing conditions were held constant but no additional motivational controls were attempted.

CHAPTER II

REVIEW OF LITERATURE

Successful hitting in the game of baseball illustrates the importance of reaction time and speed of motion. "A split-second wait is an undetermined length of time, generally about two or three-ninths of a seconds duration. With a long split-second wait, the more time the batter will have to diagnose the curves and the height of the approaching ball."[3] This statement illustrates the suddeness with which a batter must respond for successful hitting.

There is evidence that many external factors effect the speed of reaction time.[30,2,22,18,31] Increasing intensity of the stimulus shortens reaction time by strengthening in attention power.[32] Reaction time also increases as the distance between the subject and the stimulus increases.[31]

Practice of a response tends to shorten reaction time,[17,18,24,2] although Ruch states the physiological limit is soon reached.[22] Fatigue exerts a slow effect on reaction time.[18,15,23,2] Although Lawther indicates training does not affect reaction time, visual perception, which compensates for slow reaction time, will improve through training.[15]

Slater - Hammel[25] studied the relationship of reaction time to speed of movement in twenty-five male physical education students. A visual stimulus was used. Measurements of

reaction time and of speed of arm movement over a 120-degree arc were obtained. The mean reaction time of the group was .244 seconds; the mean movement time was .238 seconds. Correlations between the two measures were not statistically significant, ranging from -.07 to .17. Results show no existing relationship between reaction time and speed of movement.

Pierson[19] investigated differences between fencers and non-fencers. Various measurements included: speed of arm movement, reaction time, and finger-press reaction time. Pierson concluded, "There is no correlation in either fencers or non-fencers for speed of arm movement and reaction time, speed of arm movement and arm length, or reaction time and arm length."

"Speed is a word used to indicate various types of quickness or rapidity."[15] In sports, it may refer to either quickness in seeing or in acting, but it usually refers to a combination of perception with muscular action.[14]

Applewhaite[1] mentions the need for reaction time and speed of motion in this descriptive paragraph. "The runner crouches ready to spring forward at the crack of a starter's pistol. The rugby football back and the association football keeper crouch ready to spring in any direction, the former to get into tackle, the latter to divert or catch the ball. Slip fielders crouch down as the fast bowler starts his run up to the wicket. The tennis player needs to be as quickly off the mark as any of the players, if not quicker. It has been calculated that in international tennis, the service has

travelled at over 125 miles per hour, and is sent on its way only 78 feet from you."

Further reference to tennis by Driver[5] states that quick body action is necessary in proper foot work. The essentials of good stroking include accuracy and speed.

The factors determining the speed of response in a simple reaction are undoubtedly very complex and include more than one organic variable. Myers believes that reaction time is dependent upon the time occupied at the peripheral sense organ.

According to Woodworth,[31] a simple reaction time depends upon the subjects being prepared or "ready" to receive the stimulus or to perform an act.

In an experiment by Rasch[21] the length, strength, and weight of the arm and its segments were measured and correlated with the maximum speed of voluntary movement. From the experimental findings recorded there was no statistical significant correlation between the speed of voluntary movements of the hand, forearm and arm and the weight, length, strength of the arm and it's segments. It may be concluded from the experimental results of this study that no relationship could be found between speed of arm movement and size or weight of the arm. Apparently the inertia of the larger arm is adequately overcome by superior mechanical and muscular components.

Smith[26] studied the individual differences in strength, reaction, latency, mass and length of limbs, and their relation to maximal speed of movement. A conclusion drawn from

this study was that individual differences in speed of limb movement are almost completely unrelated to measured static strength or the ratio of static strength to limb mass.

Koepke and Whitson[13] found that there was no definite relationship between height, weight, whole arm length, forearm length, size of upper arm at biceps or size of wrist and power and velocity attained by a subject.

Henry and Whitley[10] determined the relationships between strength, speed, and mass in an arm movement. Their results support the conclusion that individual differences in static strength cannot predict "strength in action," in particular as it is exhibited by maximal speed of movement in a 90 degree horizontal arm swing from the shoulder pivot. Neuromuscular control patterns are apparently specific and different when the muscle is moving a limb as compared with causing simple static tension. The data strongly suggests that the acceleration curve for the arm movement is predominantly ballistic rather than linear. The correlation between reaction time and movement time was not significant ($r = .059$).

Another study was conducted by Henry[9] to study the factorial structure of speed and static strength in a lateral arm movement. "Speed of movement in a lateral adductive arm swing was timed at seven equidistant points on an arc of 120 degrees. Static strength and effective arm mass were measured in the movement position." The following conclusions were drawn from this study. (1) Measured static strength available for a movement, and speed in that movement, are

possibly correlated to a slight degree; the relationship is difficult to establish and too small to be of practical importance. (2) The low relationship between static strength and speed of movement supports the hypothesis of high neuromuscular specificity."

Henry, Lotter, and Smith[11] conducted a similar study concerned with the factorial structure of individual differences in limb speed, reaction, and strength. "Factor analyses were made of reaction time and maximal limb speed measurements of six movements, using a sample of 80 college men. Measurements of reaction time, speed, strength, and the ratio of limb strength, to limb mass in four movements were also analyzed." This study showed that there is a factor of limb speed that is unrelated to the reaction factor. "This speed factor is characterized by relatively low saturation." "There is a factor of limb strength as such, that has a common element of body size. It is moderately correlated (.52) with the strength/mass factor and has about the same saturation."

A study by Clarke and Henry[4] considered the neuromotor specificity and increased speed from strength development. "Arm strength, effective arm mass, and speed in a lateral adductive arm movement were measured in 62 college men and remeasured ten weeks later. During this interval, half of the subjects were given weight training exercise that did not involve the movement, while the other half remained inactive in order to provide a control group. The average of the training group improved significantly in speed,

strength, and strength/mass ratio, whereas the average of the control group declined. There was no correlation between individual differences in speed and strength/mass ratio, but individual changes in the ratio correlated significantly (r = .405) with individual changes in speed. Reaction time was not improved by weight training.

Zorbas and Karpovich[33], while studying the effect of weight lifting upon the speed of muscular contractions, found that weight lifters were faster in their rotary motions of the arm than the non-lifters.

Wilkins[29] conducted a study to determine the effect of weight training on the speed of movement. His results showed that strength may create speed, but strength gained from weight lifting does not greatly help to turn a crank faster or if it does, the effort is balanced out by an equal decrease in speed from muscle-boundness. The sign of the correlation (-.268) is also in the wrong direction. Wilkins drew the following conclusions from his study. "(1) Weight training over a period of one semester has no slowing effect on speed of arm movement as measured in the study. (2) A semester program of weight training does not increase speed of movement more than a semester of beginning swimming or golfing."

Swegan, Yankosky, and Williams[28] studied the effect of repetition upon the speed of a simple body movement. The training device utilized a chronoscope which measured the interval from the releasing of a micro-switch to the interrupting of a light beam striking a photo-electric cell.

From this three conclusions were drawn. (1) Individuals vary considerably in successive repetitions of the simple movements of preferred-arm extension. (2) Repetition, as a form of warm-up, tended to produce faster movement times on a simple arm movement. (3) The more trials that were given, the more significant became the difference in the means. Fifty trials resulted in faster movements than did twenty trials.

Pierson[20] conducted a study to determine the relationship of movement time and reaction time from childhood to senility. "Four hundred male subjects between the ages of 8 and 83 were measured for reaction time and movement time. A statistical analysis of the data permits the conclusion that reaction time and movement time are significantly related ($r = 0.56$).

Henry[10] reported an experimental study that was concerned with two problems that are related to this study. "(1) The basic degree of relation, or absence of relation, between individual differences in reaction time and in speed of movement. (2) The role of sensory stimuli that function to improve speed of action when administered to the subject during the slower half of his successive responses to a reaction signal." Movement time was computed by subtracting reaction time from total time. The reaction time and movement time were found to be independent and uncorrelated ($r = 0.07$). "Results of motivation can be secured with either a light or a sound stimulus; it is not necessary to use electric shock if that is considered to be undesirable."

Fairclough[6] found no appreciable difference between sound and shock in causing reaction time improvement either in direct motivation on the hand or in transferred motivation to the foot; in movement time, evidence for differential effects were inconclusive. There was not significant intercorrelation between speed of reaction and speed of movement, or between transferred improvement in reaction and movement.

Lotter,[16] while studying the effect of fatigue and warm-up on speed of arm movement, found that warm-up exercises were without effect under the conditions of his experiment.

Summary

In contrast with early beliefs that there was a significant correlation existing between reaction time and movement time, the literature, with the exception of Pierson's study[20], now indicates that there is no relationship.

As previously mentioned (Henry[8]) electrical shock stimulus is not necessary in this type of study if that is felt to be undesirable. The auditory stimulus is quite satisfactory.

CHAPTER III

METHODOLOGY

The purpose of this study is to compare training methods designed for the improvement in speed of lateral dominant arm movement.

Sixteen undergraduate service course students served as subjects who were divided into four groups. The criterion for the grouping of subjects was movement time measured in milliseconds. The testing range was the pre-determined twenty-inch distance from the micro-switch to the electric eye beam. This was a lateral range from right to left.

Prior to the initial test, each subject was allowed to practice the lateral movement fifteen times so that they were familiarized with the apparatus. The four groups were given demonstrations and complete instructions as to the procedure they must comply with. They were asked to do as well as they could but were not aware of the intended results.

Testing Environment

The testing and training procedures were administered in Jenison Gymnasium. The room temperatures were constant between 68-72° F. The room used for this study was located in the basement portion of Jenison. Another study was being conducted in this room but seldom were there conflicting

times between the two studies.

Training Procedures

The subjects were trained in a seating position identical to the position they assumed when being tested. It was felt that this would help isolate the purpose of training. The four groups were required to train three times (Monday, Wednesday, Friday) per week for five weeks.

Group A, the control group, was tested initially and finally. The author asked these subjects to continue with their normal daily routine but not to become involved in any training programs that might involve the upper extremities.

Group B, the training repetition group, was required to perform the designed lateral movement from right to left twenty-five times, three days per week for five weeks with maximum effort. The palm of the hand was facing to the left in the direction of movement. The movement started at point X (the micro-switch) and travelled twenty inches to the left. The subject was allowed to "follow through" beyond the twenty-inch point.

Group C, the maximum overload group, trained within the twenty-inch testing range. The procedure included a series of three trials with a three minute rest period separating the trials. Each individual trial consisted of six successive maximum overload exercises. The equipment used consisted of a handle with an attached rope extending through a pulley to a fixture capable of securing the necessary weights.

Group D, the isometric training group, trained with five maximum contractions held for six seconds each. The subjects were given a ten second rest between each contraction. The point of contraction was a post extending perpendicularly from a table so fixed as to assimulate point zero of the testing range.

Testing Apparatus

The testing apparatus consisted of a stimulus unit, a response unit, and a recording unit.

The stimulus unit (buzzer) was given by the "Athletic Performance Analyzer." This piece of equipment is a model AC 581 manufactured by the Dekan Timing Devices Company of Glen Ellyn, Illinois. It has an automatic starter with an adjustable delay of one to three seconds between "set" and sound.

The reaction key and electric eye were twenty inches apart. They were mounted on a heavy table. The electric eye beam was perpendicular to the table. This comprised the response unit.

The timing unit consisted of two separate pieces of equipment. The "Athletic Performance Analyzer" recorded the reaction time in 1/100 of seconds. The movement time was recorded by a separate unit in milliseconds.

Testing Procedure

The subjects were seated in front of the apparatus, arm extended, with the side of their right hand depressing the micro-switch. Upon auditory excitation of the buzzer,

the subjects moved their arm, in an extended position, laterally to the left through the twenty-inch range. When the hand, or wrist, contacted the light beam striking a photo-electric cell, the milliseconds unit device stopped, thus recording his movement time.

The apparatus was so arranged that the "Athletic Performance Analyzer" measured the duration between the auditory stimulus and the release of the micro-switch. The milliseconds unit measured the time from the release of the micro-switch and the interruption of the electric eye beam.

Statistical Methods

Means were computed for the reaction time and movement time scores of each group. The difference between the means of the initial test and the final test were computed.

The differences between the group means were compared using the Duncan Multiple Range Test.[27] The relationship between reaction and movement times was determined using rank-order correlations.[12]

CHAPTER IV

ANALYSIS OF DATA

The purpose of this study was to assess several training methods for their effect on speed of movement. A secondary issue as to correlate reaction time and speed of motion. Sixteen undergraduate service course students served as subjects. The subjects were divided into four groups. Subjects were matched on movement time. Letters A through D were used to identify the groups and numbers one through four were used to identify the matched subjects. The testing range was a pre-determined twenty-inch distance from a micro-switch, mounted on a normal-sized office desk, to a photo-electric cell, set up at the edge of the desk. (Fig.1) The training programs included a control group, repetition group, isotonic group, and an isometric group. All training was done within a simulated twenty-inch range. (Fig. 2 shows isotonic training set up) The plane of movement was a right arm, horizontal movement from right to left from the shoulder pivot.

To allow for practice scores to be excluded, and to simplify statistical computations from the raw data, the subjects were given fifteen practice trials during the initial testing program. Because of mechanical difficulty with the apparatus, only three measurements were recorded

following the practice trials. The final test included twenty-five trials. The mean was computed from the last ten scores as recommended.

The mean movement time of the initial scores was: group A - .1145, group B - .1450, group C - .1450, and group D - .1465 seconds. (Table 1) The mean movement time of the final scores was: group A - .1277, group B - .1172, group C - .1202, and group D - .1048 seconds. (Table 1)

There was no significant improvement between the groups with the exception of group A versus group D. (Table 2) The author observed that two of the subjects in group D were greatly motivated during the final test. It is believed that this could have had a great effect on the significant improvement shown by group D.

The mean reaction time of the initial scores was: group A - .190, group B - .196, group C - .183, and group D - .169 seconds. (Table 1) The mean reaction time of the final scores was: group A - .169, group B - .178, group C - .172, and group D - .164 seconds. (Table 1) There was no significant improvement between the groups. (Table 2)

Correlation coefficients were computed between the initial reaction time and movement time scores and between the final reaction time and movement time scores. The correlation coefficient results of the initial scores was -.282 and the correlation coefficient of the final scores was a .239. These are low correlations and substantiate other findings that little or no relationship exists between reaction time and speed of motion.

Figure I

Testing Apparatus

Figure II

Isotonic Training

TABLE I

MEAN VALUES REACTION AND MOVEMENT
TIMES FOR INITIAL AND FINAL TESTS

		Reaction Time - 1/100 Seconds			Movement Time - 1/1000 Seconds		
	Groups	Initial	Final	Diff.	Initial	Final	Diff.
Control	A-1	.183	.159	.024	.1500	.1362	.0138
	A-2	.193	.199	-.006	.1617	.1533	.0084
	A-3	.227	.163	.064	.1393	.1134	.0259
	A-4	.157	.158	-.001	.1273	.1079	.0194
	Mean	.190	.169	.040	.1445	.1277	.0168
Repetition	B-1	.185	.198	.013	.1517	.1125	.0392
	B-2	.177	.166	.011	.1570	.1326	.0244
	B-3	.227	.177	.050	.1390	.1115	.0275
	B-4	.198	.174	.024	.1323	.1125	.0198
	Mean	.196	.178	.024	.1450	.1172	.0277
Isotonic	C-1	.177	.155	.022	.1513	.1244	.0269
	C-2	.233	.205	.028	.1613	.1136	.0477
	C-3	.178	.153	.025	.1357	.1070	.0287
	C-4	.147	.175	-.028	.1320	.1358	-.0038
	Mean	.183	.172	.015	.1450	.1202	.0331
Isometric	D-1	.170	.175	-.005	.1520	.1097	.0423
	D-2	.183	.149	.034	.1653	.1017	.0636
	D-3	.137	.162	-.025	.1377	.1068	.0309
	D-4	.188	.170	.018	.1313	.1010	.0303
	Mean	.169	.164	.011	.1465	.1048	.0417

TABLE II

DUNCAN MULTIPLE RANGE TEST RESULTS

Reaction Time				Movement Time			
Control	Repetition	Isotonic	Isometric	Control	Repetition	Isotonic	Isometric
.169	.178	.171	.163	.1277	.1172	.1202	.1048
	2	3	4		2	3	4
	2.92	3.07	3.15		2.92	3.07	3.15
	.126	.133	.136		.0197	.0207	.0212

A vs B = NS
A vs C = NS
A vs D = NS
B vs C = NS
B vs D = NS
C vs D = NS

No differences were statistically significant.

A vs B = NS
A vs C = NS
A vs D = S
B vs C = NS
B vs D = NS
C vs D = NS

Group I significantly faster than Group IV
no other differences were statistically significant.

CHAPTER V

SUMMARY, CONCLUSION, RECOMMENDATIONS

Summary

This study was designed to investigate the effects that several straight training methods have upon the speed of movement. A secondary issue was to compute a correlation coefficient between reaction time and movement time. Sixteen undergraduate service course students served as subjects. They were divided into four groups. The criterion for grouping was movement time measurements recorded in milliseconds. The training programs included: a control group, repetition group, isotonic group, and an isometric group. The testing apparatus consisted of a stimulus unit, a response unit, and a recording unit. (Fig. 1) The testing procedure was as follows: upon auditory excitation of a buzzer, the subject moved his dominant arm in an extended position, laterally to the left through a twenty-inch range. When the hand or wrist contacted the beam produced by the photo-electric cell, a millisecond timing device stopped, thus recording his movement time. The "Athletic Performance Analyzer" measured the duration between the auditory stimulus and the release, of a micro-switch. This was the subjects reaction time and it was recorded in 1/100's of a second.

Conclusions

(1) The results of this study show that movement time was not significantly improved through repetition, isotonic or isometric training. The one significant improvement appearing between the control group and the isometric group is not sufficient evidence to warrant a positive conclusion.

(2) Reaction time was not significantly improved by repetition, isotonic, or isometric training programs.

(3) Reaction time and movement time were not significantly correlated.

Recommendations

(1) A study of total body reaction time and movement time should be conducted.

(2) At least forty subjects should be used for a study of this nature.

(3) The results of this research should be verified by a similar study.

(4) If a similar study is conducted, the training programs should last at least ten weeks.

(5) The subjects should be tested thirty times with the mean being derived from the last fifteen trials.

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APPENDIX

APPENDIX A

RAW DATA

Initial Results						Final Results											
Subj.	RT	MT	Subj.	RT	MT	Subj.	RT	MT	Subj.	RT	MT	Subj.	RT	MT	Subj.	RT	MT
A-1	.20	.157	C-4	.15	.125	A-1	.16	.150	B-1	.18	.103	C-1	.16	.133	D-1	.18	.121
	.18	.142		.14	.135		.15	.136		.20	.099		.26	.132		.16	.107
	.17	.151		.15	.136		.16	.139		.18	.118		.16	.132		.15	.111
							.15	.132		.22	.098		.13	.105		.16	.100
A-2	.21	.160	D-1	.15	.146		.18	.132		.18	.112		.15	.103		.16	.123
	.19	.160		.19	.149		.17	.134		.18	.112		.12	.126		.25	.111
	.18	.165		.16	.161		.16	.127		.18	.113		.12	.130		.18	.108
							.14	.132		.16	.122		.13	.130		.17	.099
A-3	.19	.135	D-2	.17	.179		.15	.140		.21	.132		.15	.135		.18	.109
	.27	.145		.21	.171		.15	.140		.28	.116		.16	.118		.15	.108
	.22	.138		.17	.145												
						A-2	.23	.168	B-2	.16	.136	C-2	.18	.124	D-2	.12	.100
A-4	.18	.141	D-3	.14	.130		.19	.160		.19	.129		.32	.114		.16	.103
	.14	.126		.14	.135		.22	.157		.18	.137		.18	.122		.14	.098
	.15	.115		.13	.148		.23	.158		.16	.128		.14	.129		.15	.102
							.23	.140		.15	.143		.19	.105		.14	.098
B-1	.19	.158	D-4	.19	.133		.20	.145		.15	.130		.19	.105		.17	.157
	.19	.153		.20	.144		.18	.146		.14	.134		.19	.103		.17	.104
	.17	.144		.17	.117		.19	.152		.15	.131		.18	.113		.14	.088
							.21	.157		.17	.132		.16	.106		.13	.073
B-2	.19	.166					.15	.150		.19	.126		.32	.115		.15	.094
	.18	.150															
	.16	.155				A-3	.19	.115	B-2	.18	.111	C-3	.15	.122	D-3	.15	.098
							.14	.105		.18	.098		.13	.112		.21	.067
B-3	.26	.138					.14	.105		.20	.110		.14	.098		.14	.090
	.22	.138					.16	.123		.17	.128		.21	.118		.16	.117
	.20	.141					.15	.113		.17	.118		.13	.096		.19	.120

APPENDIX A CONTINUED

Subj.	RT	MT	Subj.	RT	MT	Subj.	RT	MT	Subj.	RT	MT	Subj.	RT	MT	Subj.	RT	MT
						A-3	.20	.126	B-3	.20	.114	C-3	.14	.107	D-3	.13	.121
B-4	.21	.150					.16	.105		.21	.110		.18	.110		.15	.123
	.17	.119					.17	.128		.14	.116		.16	.100		.18	.118
	.21	.128					.15	.110		.17	.108		.14	.105		.15	.117
							.16	.104		.15	.102		.13	.102		.15	.115
C-1	.18	.142															
	.17	.151				A-4	.15	.103	B-4	.16	.112	C-4	.20	.144	D-4	.15	.097
	.18	.161					.15	.095		.16	.114		.17	.131		.17	.095
							.17	.095		.16	.117		.17	.139		.15	.096
C-2	.21	.168					.19	.103		.15	.116		.20	.144		.14	.096
	.21	.156					.15	.110		.18	.115		.15	.143		.18	.109
	.28	.160					.15	.102		.21	.105		.19	.143		.14	.099
							.16	.120		.18	.113		.18	.129		.16	.100
C-3	.19	.144					.17	.124		.15	.112		.16	.128		.22	.102
	.17	.134					.15	.110		.18	.107		.14	.115		.23	.110
	.17	.129					.13	.117		.20	.114		.18	.142		.16	.106

APPENDIX B

ANALYSIS OF VARIANCE TABLE

Reaction Time

Source	Sum of Squares	Degrees Freedom	Estimated Mean Square	"F"
Total	.959	-	-	-
Treatment	.054	3	1.813	.215
Subject	.148	3	4.957	.590
Error	.756	9	8.50	-

Movement Time

Source	Sum of Squares	Degrees Freedom	Estimated Mean Square	"F"
Total	.3756	15	-	-
Treatment	.1292	3	430.96	2.359
Subjects	.0819	3	273.07	1.495
Error	.1644	9	182.68	-

F required for P .05 for 3 and 9 df = 3.86