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The effect of overload training on movement time of the forehand tennis stroke

June Nutter

University of Nebraska at Omaha

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THE EFFECT OF OVERLOAD TRAINING ON MOVEMENT TIME OF THE FOREHAND TENNIS STROKE

A Thesis
Presented to the
School of Health, Physical Education and Recreation and the
Faculty of the Graduate College

University of Nebraska at Omaha

In Partial Fulfillment of the Requirements for the Degree Master of Arts in Physical Education

by

June Nutter
December 1981
THESIS ACCEPTANCE

Accepted for the faculty of the Graduate College, University of Nebraska, in partial fulfillment of the requirements for the degree Master of Arts in Physical Education, University of Nebraska at Omaha.

Committee

<table>
<thead>
<tr>
<th>Name</th>
<th>Department</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

Chairman

Date: December 16, 1981
ACKNOWLEDGEMENT

I wish to thank the members of my committee, Dr. Kris Berg and Dr. Larry Stephens, for their help and patience. I would also like to thank Dr. Larry Albertson for serving as chairperson. I would also like to thank my husband for his patience, guidance, and typing ability.
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Coaches and physical educators are constantly searching for ways to improve individual performance. New training techniques are introduced every season. Weighted belts, vests, ankle and wrist straps, and weighted balls and bats are techniques used by many coaches. These training techniques are often referred to as overload training because the athletes wear weights on their bodies or use heavier than regulation weight equipment to provide resistance (overload) as they practice a specific range of motion. Among the expected benefits are increases in the specific performance variables of strength, power, accuracy, and speed, which may in turn boost overall athletic performance.

Overload training is based on the principle of neuromotor specificity formulated by Franklin Henry. According to this principle, large muscle movement time is specific to the task and direction of movement to be performed. Maximal movement time is determined by specific neuromotor coordination. A low correlation between static strength and speed of movement indicates that there is a separate neuromotor coordination for movement speed and a
separate one for static strength (Henry and Whitley, 1960; Clarke, 1960; Smith, 1961; Lotter, 1961; and Clarke and Henry, 1961). In other words, movement speed is not dependent upon the static strength of a muscle but upon efficient functioning of the nervous system.

Research done by Henry and Whitley in 1960 led them to state that full advantage of increased strength can be achieved through practice with a specific movement so that the specific neuromotor coordination can effectively utilize the greater strength potential of the muscle. Overload training simultaneously provides resistance to increase strength and practice through a specific range of motion to improve neuromotor coordination and thus improve speed of movement.

A study by Logan, et al (1966) also lends support to the belief that overload training might be effective in improving movement time. The researchers used a pulley device to provide two and one-half pounds of resistance through a throwing range of motion exercise to significantly increase the velocity of a thrown ball over that of a control group. They concluded that resistance through a range of motion should be relatively light to produce significant improvement in performance.

A skilled tennis player may be described as one who hits the ball with power and pace (rapid velocity). Power is imparted to the ball by the transfer of weight by the
legs as the player steps into the ball in combination with the racket swing. According to Murphy and Murphy (1978), strong hand, wrist, and forearm muscles are required to overcome the resistance of the fast-moving ball, to maintain a firm grip which prevents wrist movement, and to swing the racket rapidly to add power to strokes. Wells and Luttgens (1976) maintain that the speed with which the racket is swung forward is important because the speed of the racket in combination with the transfer of weight determines the distance the ball will travel. The firm grip on the racket allows the maximum amount of force developed from the speed of the swing to be transferred to the ball upon impact. The firm grip also helps to prevent the racket from twisting or turning in the hand upon impact resulting in a consistent racket face position which determines ball placement on the court.

Purpose and Significance of the Study

The purpose of this study was to ascertain the effect of overload training on the movement time of the forehand ground stroke. More specifically, the purpose of this investigation was to determine the effectiveness of hitting tennis balls against a wall with a forehand stroke while wearing a one pound wrist weight to improve the movement time of the forehand stroke.
This study may provide an effective technique to improve the speed of beginning female tennis players' forehand strokes. In addition, the study of overload training in tennis will help to further clarify the belief that overload training is beneficial.

Hypothesis

The hypothesis of this study was stated in the null form: There would be no significant difference in movement time due to overload training.

Limitations

This study was limited to the female volunteers enrolled in five beginning tennis classes at the University of Nebraska at Omaha in the fall semester of 1981 who were under thirty years of age. It was further limited to two training sessions per week since the tennis classes met two days a week. The training period was limited to six weeks to allow the participants sufficient time between the completion of the study and the beginning of the skill testing period to practice and improve their tennis skills outside of class.

Definition of Terms

Since the terms strength training and weight training employ the application of the overload principle to produce an increase in strength, they may be easily
confused with the term overload training. Overload training, as it was used in this study, was defined as the repetition of a movement through a specific range of motion using an object or implement heavier and/or larger than the one used in performance to provide resistance in an attempt to improve performance.

Movement time was defined as the time between the beginning of a movement to the completion of the movement. In this study, only a small portion of the forehand stroke was used to determine movement time. The completion of the forehand stroke occurred when the racket was in the same plane as the forward foot or at the ideal point of ball contact. The beginning of the stroke occurred eighteen inches before the ideal point of ball contact.

The forward foot of the subject was defined as the foot which is nearer the net in the forehand swing during actual playing conditions. The forward foot of a right-handed subject was the left foot.

The back foot of the subject was defined as the foot which is farther from the net in the forehand stroke. It was the right foot of a right-handed subject.
CHAPTER II

REVIEW OF LITERATURE

A review of the related literature revealed that a number of studies have investigated the effects of overload training upon various performance variables. More specifically, studies have been conducted investigating the effects of overload training upon power, accuracy, and speed. In order to present the related literature in an orderly fashion, this chapter is organized in the above mentioned categories.

Effect Upon Power

Studies have investigated the effects of overload training upon power as measured by vertical jumping and shot putting. These studies are reviewed in this section.

Anderson (1961) studied the effect of weighted ankle spats upon vertical jumping performance, agility, and endurance. An experimental group of five subjects practiced with ankle spats weighing a total of three pounds, while a control group of five subjects did not use weights. Both groups trained three days a week for six weeks. Each training session lasted sixty minutes. Activities used during the training sessions were: rope jumping, lap running, intragroup volleyball games, relays, and running
bleacher steps. The Sargent Jump Test, the Illinois Agility Run, and a 360 yard shuttle run were used to test vertical jumping, agility, and endurance. The results indicated a significant improvement in the height of a standing vertical jump beyond the .05 level of significance in favor of the overload group over the control group. There were no significant differences in agility and endurance. Anderson concluded that the use of overload training significantly increased vertical jumping height.

Boyd (1969) designed a study similar to Anderson's but obtained different results. Boyd used twenty-four high school basketball players who trained for six weeks using ankle weights while performing a prescribed set of exercises. Boyd divided the subjects into three groups; Group A trained without weights, Group B used a total of three pounds, and Group C used a total of six pounds. The prescribed exercises were pushups, situps, squat jumps, and running in place. Each group demonstrated significant improvement in vertical jumping ability (p<.01). Boyd concluded that, over a six week training period, ankle weights were not needed to increase vertical jumping ability.

Bierley (1961) studied the effects of overload training and weight training upon vertical jumping. Nineteen subjects participated in this ten week study. One group in the study trained by doing a specific number
of situps, heel raises, bench presses, bicep curls, and walking squats at various weights specific to the individual's strength. Another group participated in a physical education program of basketball, tumbling, handball, and track and field plus an overload jumping program. These subjects trained by swinging progressively heavier dumbbells with their arms to help them jump as high as possible. The subjects began with five pound dumbbells and increased to twenty-five pounds. The third group did the weight training and the overload jumping. No control group was used. In addition, all three groups took twenty maximal vertical jumps at each session without weights. The Sargent Vertical Jump Test was used to test vertical jumping. The results led Bierley to conclude that 1) weight training, overload jumping, and a combination of overload jumping and weight training significantly improved jumping scores and 2) that there were no significant differences among the final means. However, Bierley's findings were limited by the absence of a control group and the small number of subjects in each group.

Feeney (1971) studied the effects of overload and underload training upon power as measured by shot put distance. Sixty-two seventh and eighth grade boys were assigned to one of three groups by using a matched pairs system. The underload group practiced with a six pound shot and the overload group used a twelve pound shot. The
control group used a regulation eight pound shot for practice. Each subject put the designated shot ten times daily the first week, fifteen times the second week, and twenty times the third week. Subjects put their assigned practice shot three times to warm up and then put a regulation eight pound shot three times as a post-test. The best distance score was used for statistical comparison. Each group significantly improved their shot put distance (p<.01). However, further statistical analysis revealed no significant difference in performance between the groups. Feeney concluded that overload or underload training methods did not create a significant difference in regulation eight pound shot put performance for seventh and eighth grade boys.

Effect Upon Accuracy

Studies have been conducted which investigated the effects of overload training upon accuracy in throwing baseballs and footballs and in shooting free throws. These studies are reviewed in this section.

In 1964 Sinks found that a six week training program in which subjects threw weighted baseballs two times a week produced a significant decrease in the accuracy of throwing in a group of pitchers. During the training period, the experimental group warmed up with a regulation weight baseball and then threw eight minutes
with progressively heavier balls each week. The control group threw only regulation weight baseballs. The test procedure consisted of throwing ten regulation baseballs at a target after a warm-up with the regulation ball. Accuracy was determined by awarding points for the distance from the target point. Statistical analysis revealed that the experimental group was significantly less accurate (p<.05) than the group which threw only regulation balls.

Brose and Hanson (1967) also tested the effects of overload training upon the accuracy of thrown baseballs but were unable to find significant differences between overload training and traditional methods. One experimental group threw weighted balls of ten ounces while the other experimental group used a pulley device to provide ten pounds of resistance to the throwing motion of the subjects. The control group threw a regulation ball. Training was done three days a week for six weeks. The testing procedure consisted of throwing a regulation baseball twenty times for maximal velocity and accuracy. None of the groups were able to significantly improve their accuracy which led Brose and Hanson to conclude that overload training did not affect baseball throwing accuracy.

Straub (1968) also studied the effects of overload training upon the accuracy of thrown baseballs. The
control group threw regulation five ounce balls during the training period. Three experimental groups threw progressively heavier balls, beginning with seven ounce balls and finally throwing seventeen ounce balls during the sixth week. Each experimental group received different combinations of speed and accuracy emphases during the training. The control group had equal speed and accuracy emphases. Each group threw twenty balls each session three days a week for six weeks. At the end of the training period there were no significant differences between group means in accuracy.

Hopek (1967) investigated the training effect of throwing a weighted football for accuracy. Two groups of six college age males with game experience in passing a football trained for seventeen days by throwing a weighted or a regulation football. Both groups threw the regulation football at a swinging bicycle tire at distances of ten and fifteen yards to test their accuracy. Hopek found that both groups improved their accuracy but the improvement was not statistically significant. In addition, there was no significant difference between the gains made by either group.

In 1965 Jable studied the effects of training with basketballs of different weights on free throw performance. Sixty subjects were assigned to three groups on the basis of their pre-test scores. One group trained with a
regulation weight basketball (twenty-one ounces), another with a lightweight ball (fifteen ounces), and the third group used a heavyweight ball (forty ounces). Each group shot twenty-five free throws per session three times a week for five weeks with the assigned ball. The test consisted of twenty-five free throws with the regulation ball. The results indicated that the regulation ball group and the light ball group significantly improved their free throw shooting but there was no change in foul shooting for the heavy ball group. Further analysis indicated that the regulation ball group did significantly better than the heavy ball group when they were tested with the regulation ball (p<.05).

Effect Upon Speed

Studies have investigated the effects of overload training upon speed of movement as measured by agility running, ice skating speed, and indirectly measured by the velocity of a thrown ball. These studies are reviewed in this section.

Winningham (1966) studied the effects of ankle weight overload training upon agility running and sprinting. He developed a type of maze which required subjects to make quick decisions and to make quick changes of direction. This type of maze was an attempt to closely approximate the movements and decisions which players must make in
vigorous team game situations. He divided 120 college students into four groups: group one trained without ankle weights, group two wore two pounds on each ankle, group three used five pounds on each ankle, and group four received no training. Each of the three experimental groups trained by using the maze twenty-one times in six weeks. The experimental groups were able to significantly improve their maze running times (p<.05) while the control group did not improve. However, there were no significant differences in the final performance in the maze run among the groups that trained with the weights and the group that trained without the weights. Winningham concluded that the use of the ankle weights did not aid the development of a type of running skill that was associated with vigorous team sports. Times in the 100 yard dash were significantly slower for those subjects who trained with the weights which led Winningham to suggest that overload training may impair the development of sprint speed.

Kober (1971) studied the effect of training with ankle weights on forward ice skating speed. Sixteen high school varsity ice hockey players were matched on the basis of their forward ice skating speed and randomly assigned to two groups. Both groups participated in formal one hour practice sessions which included warm-ups, skating drills, and scrimmages for nine weeks. The experimental group wore the two pound ankle weights and
the control group did not. Forward skating speed was determined by using the best time of three trials to skate between the ice hockey rink blue lines and back for a total of sixty feet. The results indicated that the improvement for each group was not significant. Kober concluded that the use of ankle weights did not aid the development of forward ice skating speed.

Sinks (1964) investigated the effects of overload training on throwing velocity in addition to the previously described effects on accuracy. In this study the experimental group threw progressively heavier baseballs for six weeks. The results indicated that the experimental group threw significantly faster than the group which threw regulation baseballs (p<.01).

Elias (1964) attempted to determine if a six week conditioning program using overweight baseballs in practice would improve baseball pitching speed. Twelve freshman pitchers from Michigan State served as subjects. The control group threw regulation five ounce baseballs for twenty minutes three days a week during the training period. The experimental group warmed up with a regulation weight ball for eight minutes. After the warm-up they threw an overweight ball for eight minutes and the regulation ball for the last four minutes of each practice session to regain the feel of the regulation ball. The testing procedures consisted of throwing 100 pitches as fast as
the subjects could. One hundred pitches were determined
to be the average number of pitches in a regulation length
baseball game. The experimental group made significant
gains in velocity (p<.05) but the control group did not.
However, the gains were not great enough for significant
differences to exist between the groups.

Logan et al (1966) studied the effect of overload
training upon baseball throwing velocity and found that
velocity was significantly increased by overload training.
In this study, one experimental group used an isotonic
resistance device (the Exer-genie) to provide 2.5 pounds
of resistance to an overhand throwing motion. Another
experimental group threw a regulation ball thirty times a
day, five days a week for six weeks. The third group took
only the pre- and post-tests. Each group threw the
regulation weight balls during the test. The subjects in
the resistance group significantly increased their throwing
velocity over that of the other groups (p<.05). Logan et
al concluded that baseball throwing velocity could be
significantly increased by applying moderately light
resistance through the overhand throwing range of motion.

Brose and Hanson (1967) tested the effects of
overload training upon the velocity of thrown baseballs in
addition to the previously described effect on accuracy.
Both experimental groups in the study had significant
gains in velocity (p<.05). However, further statistical
analysis revealed that the velocity gains made by the two experimental groups were not great enough for the overload training methods to be considered superior to traditional methods. Therefore, Brose and Hanson concluded that the throwing of weighted balls or the use of a wall pulley did not significantly affect baseball throwing velocity.

Straub (1968) studied the effects of overload training upon the velocity of thrown baseballs. Different combinations of speed and accuracy emphases were used during the study. Each group threw twenty balls each session three days a week for six weeks. The results indicated no significant differences (p > .05) in throwing velocity among groups. Straub concluded that the use of progressively heavier balls did not result in long range improvements in throwing velocity.

Summary

Research on the effect of overload training has been somewhat contradictory and confusing. Many studies have shown a significant improvement in performance due to overload. However, the improvement due to overload training was not great enough in most studies to be significantly better than the improvement due to traditional methods.

Overload training did not appear to have a significant effect upon power as indicated by vertical
jumping and shot put distance. The effect of overload upon throwing baseballs and footballs for accuracy and upon shooting free throws was inconclusive. Overload training may or may not have a negative effect upon accuracy. It appeared from the literature that overload training did not significantly affect speed of movement. However, the effect of overload training upon baseball throwing velocity was inconclusive. When all performance variables were considered, it appeared that overload training did not significantly affect performance when compared to traditional methods.
CHAPTER III

PROCEDURE

Subjects

Nineteen female volunteers, who were enrolled in beginning tennis classes offered during the fall semester of 1981 at the University of Nebraska at Omaha, served as subjects. Participation in the study was limited to students in the classes who were under thirty years of age. In addition, the subjects were not allowed to participate in weight training, racquet sports, or extra-curricular tennis practice during the study. Nineteen subjects took the pre-test. One subject dropped the tennis class and another received an injury which resulted in seventeen subjects taking the post-test.

Description of the Testing Device

The following equipment was used to measure the movement time of the forehand swing:

1. One Dekan Automatic Performance Analyzer.
2. Two line control accessories to the Dekan Performance Analyzer. A line control accessory is a small aluminum box that has a plug on the bottom and a switch arrangement at the top. The
accessories start or stop the timer on the analyzer when the racket is swung.

3. Two line controls. A line control is a nylon cord tied to a plastic wedge. The wedge was inserted into the line control accessory and the other end of the cord was tied to the center of the racket strings. When the racket was swung, the line control pulled the wedge out of the switch portion of the accessory which started or stopped the timer.

4. One tennis racket with two line controls tied to the strings. The sixty-one inch line control started the timer and the seventy-nine inch line control stopped it.

A piece of masking tape was placed on the floor sixty and one-half inches in front of the Dekan Analyzer (See Appendix A). The tape marked the placement of the subject's forward foot. The line controls were placed in the Dekan Analyzer. When the racket was swung, the short line control pulled out of the timer when the racket was in line with the subject's back foot. This action started the timer. When the racket was in line with the forward foot, the second line control was pulled out of the timer. This action stopped the timer.
Testing Procedures

The movement time of each subject's forward swing of a forehand stroke was measured with a Dekan Performance Analyzer. The Analyzer measured the time of the forward swing to the nearest thousandth of a second. The recorded time was used to represent speed of movement, since the linear distance the racket traveled was standardized. A shorter time indicated faster movement.

The subject placed the forward foot along the tape on the floor. The foot position was marked on the tape so the starting position of each swing was identical. The other foot was positioned wherever the subject felt comfortable while swinging the racket (see Appendix A). The starting position represented the portion of the forehand stroke assumed by a player after the pivot from the ready position.

Before each testing period, each subject was required to read typed instructions (see Appendix B). When the subject finished reading the instructions, a demonstration and an oral explanation of the testing procedure were given. Each subject was instructed to take a back-swing and to fully complete the forward swing with the elbow and wrist extended, instead of flexing the wrist to swing the racket. Each subject took a total of fifteen swings with the first five swings serving as a warm-up. The first swing was very slow to allow familiarization with
the equipment. The speed of the next four swings was increased until the subject was swinging the racket as fast as possible, keeping the elbow and wrist extended. Each swing was taken at ten second intervals so the movement time could be recorded and the line controls reset. The subject was verbally informed of the time after each swing to provide motivation. The subject then took ten more swings as fast as possible. A ninety second rest was taken between the fifth and sixth recorded swings. Maximum effort and correct form were emphasized during the test.

Treatment

The seventeen subjects were enrolled in beginning tennis classes which met two days a week for fifty minutes. The subjects were randomly assigned to two groups by pulling their names out of a hat. Both groups participated in all assigned class activities. Activities included instruction in the forehand, backhand, serve, and singles and doubles rules and strategy. Practice in these skills was done by hitting with other students, against a wall and a ball machine, and by playing singles and doubles. Group C was designated the control group. Members of this group took the pre-test and the post-test (refer to Table 1). The experimental group (Group W) trained two days a week after class for six weeks. The subjects in Group W hit a tennis ball against a wall with a forehand stroke while
wearing a one pound weight on their racket wrist. The weight was worn proximal to the styloid processes of the ulnar and radial bones. The weights were manufactured by Diversified Products Corporation. During the first week of practice, Group W hit the ball thirty times. The number of times the ball was hit was increased by ten hits each week. The last week of the study, the subjects hit the ball a total of eighty times.

TABLE 1
SUMMARY OF TREATMENT

<table>
<thead>
<tr>
<th>Group W</th>
<th>Pre-Test</th>
<th>Week</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td></td>
<td>30 hits</td>
<td>40 hits</td>
</tr>
</tbody>
</table>

| Group C (Control) | Pre-Test | Class Participation | Post-Test |

During the training sessions, the subject stood forty feet from the wall, dropped the tennis ball and hit it with a rapid forehand stroke. The subject swung the racket as fast as possible while still maintaining a reasonable level of accuracy. Each subject was supervised at all times and was encouraged to "hit the ball hard" during the training sessions. Each time the subject contacted the ball with a forehand stroke, a "hit" was credited. If a backhand stroke was used, the subject was
not given a "hit." If the subject was unable to return the ball, the ball was put in motion again by the subject dropping it and hitting it.

Statistical Treatment

The Pearson Product Moment coefficient of correlation was used to compute the reliability of forehand movement times in the pre-test. An independent t-test was used to compare the pre-test scores between the groups to determine if any significant differences existed between the groups before the training started. A paired t-test was used to determine if there was significant improvement within each group as a result of the overload training or class participation. A two sample t-test was used to compare the mean gain scores of the groups. An analysis of covariance was used to make adjustments for mean differences in individual scores which existed initially in the groups and to determine the difference between groups after the training. Significance was tested at the .05 level.
CHAPTER IV

RESULTS

The Pearson Product Moment coefficient of correlation was used to compute the reliability of forehand movement times in the pre-test. The correlation between the last two recorded swings in the pre-test was .54 which was significant at the .05 level.

An independent t-test was used to determine if the groups were statistically equal before the training period began. There was no significant difference between the groups when the mean times of swings one through five, six through ten, and one through ten were used to represent each group. The mean time of swings one through ten was used as the criterion score, since ten swings were more representative of each subject's movement time. Tables 2, 3, and 4 represent the results of each t-test.
TABLE 2
T-TEST FOR COMPARISON OF PRE-TEST SCORES (SWINGS 1-5) BETWEEN GROUPS

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>t ratio</th>
<th>2-Tail Probability</th>
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</thead>
<tbody>
<tr>
<td>Group C (control)</td>
<td>.0397</td>
<td>-2.00</td>
<td>.064</td>
</tr>
<tr>
<td>Group W</td>
<td>.0471</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

aMean times measured in seconds

TABLE 3
T-TEST FOR COMPARISON OF PRE-TEST SCORES (SWINGS 6-10) BETWEEN GROUPS

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>t ratio</th>
<th>2-Tail Probability</th>
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<tr>
<td>Group C (control)</td>
<td>.0397</td>
<td>-.08</td>
<td>.935</td>
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<tr>
<td>Group W</td>
<td>.0400</td>
<td></td>
<td></td>
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</tbody>
</table>

aMean times measured in seconds

TABLE 4
T-TEST FOR COMPARISON OF PRE-TEST SCORES (SWINGS 1-10) BETWEEN GROUPS

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>t ratio</th>
<th>2-Tail Probability</th>
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<tr>
<td>Group C (control)</td>
<td>.0397</td>
<td>-1.10</td>
<td>.290</td>
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<tr>
<td>Group W</td>
<td>.0436</td>
<td></td>
<td></td>
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</tbody>
</table>

aMean times measured in seconds
Means and Standard Deviations

The mean of each subject's ten forehand swings was used as the criterion score to compute the mean score, the gain score, and the standard deviation for each group. Table 5 summarizes the results. From the table, the pre-test score of Group C was .040 seconds and the post-test score was .041 seconds. Group C was .001 seconds slower after the training period. The pre-test score of Group W was .044 seconds while the post-test score was .040 seconds. This resulted in a faster time of .004 seconds after training for the experimental group.

**TABLE 5**

**SUMMARY OF INDIVIDUAL AND GROUP PRE- AND POST-TEST MEAN SCORES, GAIN SCORES, AND STANDARD DEVIATIONS**

<table>
<thead>
<tr>
<th>Group C (control)</th>
<th>Group W</th>
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<tbody>
<tr>
<td>Pre</td>
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<tr>
<td>.043</td>
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</tr>
<tr>
<td>.056</td>
<td>.043</td>
</tr>
<tr>
<td>.027</td>
<td>.027</td>
</tr>
<tr>
<td>.040</td>
<td>.041</td>
</tr>
<tr>
<td>.009</td>
<td>.010</td>
</tr>
</tbody>
</table>

aMeasured in seconds
bA minus gain score indicated that movement time was faster after training
cMean score
dStandard deviation
Analysis of Results

A paired t-test was used to determine if there were significant changes within the groups after the training. Tables 6 and 7 present the results of the t-test for Groups C and W, respectively. Group C was .001 seconds slower after the training. The t ratio of -.33 indicated that there was no significant change within Group C (p>.05). Group W was .004 seconds faster after the overload training. The t ratio of 1.17 indicated that there was no significant change within Group W (p>.05).

TABLE 6

PAIRED t-TEST FOR WITHIN GROUP DIFFERENCES AFTER TRAINING FOR GROUP C (CONTROL)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Difference</th>
<th>t ratio</th>
<th>2-Tail Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Test</td>
<td>.040</td>
<td>.001</td>
<td>-.33</td>
<td>.753</td>
</tr>
<tr>
<td>Post-Test</td>
<td>.041</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^a\)A positive difference between the pre- and post-test means indicated that movement time was slower after training.

\(^b\)Measured in seconds.
TABLE 7

PAIRED t-TEST FOR WITHIN GROUP DIFFERENCES
AFTER TRAINING FOR GROUP W\(^a\)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean(^b)</th>
<th>Difference(^b)</th>
<th>t ratio</th>
<th>2-Tail Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Test</td>
<td>.044</td>
<td>-.004</td>
<td>1.17</td>
<td>.276</td>
</tr>
<tr>
<td>Post-Test</td>
<td>.040</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) A Negative difference between the pre- and post-test means indicated that movement time was faster after training.

\(^b\) Measured in seconds

A two sample t-test was used to compare the mean gain scores of Group C and Group W (Table 8). This test revealed a t ratio of 1.05 indicating that the mean gain scores were not significantly different (p>.05).

TABLE 8

TWO SAMPLE t-TEST FOR COMPARISON OF MEAN GAIN SCORES FOR THE EXPERIMENTAL AND CONTROL GROUPS

<table>
<thead>
<tr>
<th>Mean Gain(^a)</th>
<th>t ratio</th>
<th>2-Tail Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group C (control)</td>
<td>.001</td>
<td>1.05</td>
</tr>
<tr>
<td>Group W</td>
<td>-.004(^b)</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) Measured in seconds

\(^b\) A minus gain score indicated that movement time was faster after training.

An analysis of covariance was used to equate the groups on the basis of pre-test scores. The test for
parallelism between the groups resulted in an F value of .326. This F value revealed that an analysis of covariance could be used to compare the effects of training on the groups. The analysis of covariance, which is summarized in Table 9, revealed an F value of .212 which was not significant at the .05 level of significance. This F value indicated that there was no significant difference between the groups.

TABLE 9
ANALYSIS OF COVARIANCE FOR DIFFERENCES BETWEEN GROUPS

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>SS</th>
<th>DF</th>
<th>MS</th>
<th>F Ratio</th>
<th>2-Tail Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariate (Pre-test) Scores</td>
<td>.000</td>
<td>1</td>
<td>.000</td>
<td>4.686</td>
<td>.048</td>
</tr>
<tr>
<td>Groups</td>
<td>.000</td>
<td>1</td>
<td>.000</td>
<td>.439</td>
<td>.518</td>
</tr>
<tr>
<td>Residual</td>
<td></td>
<td>14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>16</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The sum of the squares and the mean square columns do not reveal numbers significant to the third decimal place because the figures are so small.

An analysis of covariance was used in addition to the more traditional independent t-test to compare the groups after the six weeks of training. Some statisticians believe that the analysis of covariance is a more appropriate test to use when comparing subjects of varying
skill levels. Even though the results of the independent t-test showed that there was no significant difference between the groups before the training began, some subjects were much faster than others. Those subjects who had initial fast movement times would show less improvement than those who had slower initial movement times. This fact might have affected the results of the independent t-test comparing the mean gain scores between the groups since no significant difference was found between the groups after the training. The analysis of covariance was then used to compare the groups. The results were the same indicating that the large gains made by some subjects did not affect the results of the independent t-test.
CHAPTER V

DISCUSSION

From the analysis of the results, it appeared that overload training with a wrist weight did not affect the movement time of the forehand stroke. Movement time was not significantly improved by overload training and mean gain scores were not significantly different. The analysis of covariance also revealed that there was no significant difference between the groups. Thus, the null hypothesis was accepted: There was no significant difference in movement time due to overload training. However, since the study was limited to six weeks, the effects of training or of class participation may not appear in either group for several more weeks.

Anderson (1961), Winningham (1966), Sinks (1964), and Logan et al (1966) concluded that overload training significantly improved performance over that of a control group after six weeks of training. However, the minimum number of weekly training sessions in these studies was three. Since the number of weekly training sessions in this investigation was limited to two, a significant training effect as demonstrated in the previously described
studies should not be expected to appear for several more weeks.

The movement time of Group C was slightly slower after the six weeks of class participation. The slower swing may be due simply to chance. The slightly slower movement time may also be explained by the fact that many different skills with different movements were practiced by both groups in the class. It may be possible that the movement in other types of strokes, such as the backhand, may have interfered with the development of speed or may have even decreased the speed in the forehand stroke of the control group.

Motivation of individual subjects is a factor which should also be considered. All training sessions were supervised by the researcher. Each subject was praised when maximum effort was observed by the researcher to assist in keeping motivation high. Individual subjects in Group C may not have been highly motivated to produce maximum effort on every stroke during each class period. During the testing procedure, each subject was encouraged to swing as fast as possible on every trial. After each trial was completed, the time was read aloud to provide a score to better. Even though maximum effort was emphasized during the testing period, it appeared that certain subjects were not making a maximum effort on their first trials which resulted in slower mean scores.
The results of the study confirm the findings of Kober (1971) who found that overload training did not result in significantly improved performance. It also supported the findings of Winningham (1966), Elias (1964), Brose and Hanson (1967), and Straub (1968) who concluded that overload training had no significant effect upon speed of movement when compared to traditional methods of training.

Implications for Further Research

According to the findings of this study, it appeared that overload training did not improve performance in tennis. A six week overload training method did not significantly improve the movement time of a forehand stroke of beginning female tennis players. However, the small number of subjects (N=17) greatly reduced the chance of finding significant differences between the groups. Additionally, the small number of subjects increased the chance of making a type II error (accepting the null hypothesis when it should be rejected). Only when there is a large number of subjects, can it be stated with a large degree of confidence that there are no differences between the groups. The results of the study with the addition of the just described limitations suggest the need for further study of this subject.
Problem Areas

Many beginning tennis players flex their wrists when they use a forehand stroke, instead of keeping their wrists firm. Wrist flexion before impact will result in a faster movement time when the movement time represents how rapidly the racket head is moving. The use of the Dekan Performance Analyzer does not distinguish between correct forehand form and a stroke in which wrist flexion occurs. It is impossible to determine if a fast movement time, as registered on the Dekan Analyzer, is a result of incorrect wrist flexion or of a firm, extended wrist. Only those strokes which have been properly executed should be recorded and used as data for analysis. It was not possible to record only properly executed strokes in this study since the Dekan Analyzer was used to measure movement times. The mean times used for analysis in this study may not be truly representative of some subject's movement times for the correct execution of the forehand stroke. One or two strokes in which the wrist was flexed may have lowered the subject's true mean time.

Recommendations

There is a need for more research about the effects of overload training as suggested by the results of this study. The following recommendations are made regarding further research.
1. It is recommended that a study be conducted with more subjects.
2. It is recommended that the effects of overload upon tennis movement time of male subjects be studied.
3. It is recommended that a study be conducted to determine the effect of overload upon movement time over a longer training period. The number of training sessions per week should be increased to at least three.
4. It is recommended that a study using better skilled subjects be conducted.
5. It is recommended that cinematography be used to determine the movement time of a forehand stroke in tennis.
CHAPTER VI

SUMMARY AND CONCLUSIONS

It was the purpose of this study to ascertain the effect of overload training on the movement time of a tennis forehand stroke. Seventeen female volunteers from beginning tennis classes at the University of Nebraska at Omaha served as subjects. The movement time of the forehand stroke was measured with a Dekan Automatic Performance Analyzer and recorded to the nearest .001 second.

The subjects were randomly assigned to two groups. The control group participated in the class activities and took the pre- and post-tests. The experimental group participated in the class activities and trained two times a week after class for six weeks. The experimental group hit a tennis ball against a wall with a forehand stroke a specified number of times while wearing a one pound weight on their racket wrist. The subjects hit the ball thirty times the first week and progressed to eighty times the sixth week. The analysis of results indicated that movement time was not significantly improved by overload training.
Conclusions

Within the limitations of the study, the following conclusion was warranted: A six week overload training program did not affect the movement time of the forehand stroke of college age females who were learning to play tennis.
REFERENCES


Brose, Donald E. and Hanson, Dale L. "Effects of Overload Training on Velocity and Accuracy of Throwing." The Research Quarterly of the American Association for Health, Physical Education, and Recreation (hereafter referred to as Research Quarterly), 38:528-33, December 1967.


APPENDIX A
Figure 1. Testing Equipment Set-up.
APPENDIX B
INSTRUCTIONS FOR FOREHAND TENNIS VELOCITY TEST

Your are about to take a forehand tennis velocity test. You will be given a wooden tennis racket which has 2 strings tied to it. The other ends of the strings will be tied to plastic "spacers" which will be inserted into a timing device. If you are right-handed, you will place your left foot on a piece of tape placed on the floor. If you are left-handed, you will place your right foot on the tape. Your other foot should be placed about shoulder width from the foot on the tape. Assume a comfortable position which will allow you to swing the racket in a forehand stroke.

You will swing the racket very slowly through the backswing position of your forehand stroke so you can determine the amount of backswing you can take. Then you will complete your swing at a slow speed. The racket will pull the strings out of the timer at different points of your swing causing the timer to start and stop. You will then take 5 swings at different speeds to further familiarize you with the test procedure. These 5 swings will be timed but not recorded. The tester will tell you your time for each of these swings.
The next 5 swings will be taken at high speed and will be recorded. You will be given your time for each swing. When 5 swings have been completed you will rest for 90 seconds and then take 5 more swings. This will complete your test.

Thank you very much for your help.