AN EXPERIMENTAL STUDY OF THE EFFECTS OF MENTAL PRACTICE AND PHYSICAL PRACTICE UPON MUSCULAR ENDURANCE

by

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ABSTRACT

Two problems were examined with respect to muscular endurance of the abdominal and thigh flexor muscles: first, the hypothesis that muscular endurance can be increased through mental rehearsal of a particular item of endurance; second, that the increase, if any, would be as great as, or greater than that achieved through sole physical practice of the same item.

Thirty-six subjects were selected from the required physical education programme at The University of British Columbia to engage in the experiment. They were equated into three groups on the basis of similar results obtained in two sit-up tests. One group served as a control, the second group practised sit-ups physically and the third group mentally rehearsed sit-ups. Following the initial tests the first group did not practise again for twenty days; the second group physically practised sit-ups for five minutes on each of twenty days; and the third group mentally rehearsed sit-ups for five minutes on each of the twenty days. On the final day individuals of all three groups were re-examined in the original sit-up test.

Results indicated that muscular endurance of the abdominal and thigh flexor muscles is increased significantly over a twenty day period by a daily five minute mental practice of sit-ups. It was also found, however, that the increase
was significantly smaller than that achieved by a daily five minute physical practice of sit-ups.

It was concluded that where physical practice is at all possible this method is recommended over mental practice to facilitate an increase in muscular endurance. Two recommendations of further study in the area of mental practice and muscular endurance were made.
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Date April 4th, 1959.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Statement of the Problem</td>
<td>1</td>
</tr>
<tr>
<td>II Justification of The Problem</td>
<td>2</td>
</tr>
<tr>
<td>III Review of Literature</td>
<td>5</td>
</tr>
<tr>
<td>IV Methods and Procedure</td>
<td>15</td>
</tr>
<tr>
<td>V Results</td>
<td>20</td>
</tr>
<tr>
<td>VI Discussion</td>
<td>25</td>
</tr>
<tr>
<td>VII Summary and Conclusions</td>
<td>30</td>
</tr>
<tr>
<td>Bibliography</td>
<td>32</td>
</tr>
</tbody>
</table>

## Appendices

- A Statistical Treatment ............................................. 38
- B Individual Score Card ............................................ 41
- C Blank Sheet for Recording Thoughts of Group III .................. 42
- D Daily Questions for Group III .................................... 43
- E Raw Scores for Condition I ....................................... 46
- F Daily Raw Scores and Averages of Raw Scores for Condition II ........ 47
- G Raw Scores for Condition III ..................................... 48

## List of Tables

- I Final Test Scores of Matched Subjects in the Equated Groups ........... 21
- II Improvement in Endurance Due to Practice ......................... 21
- III Comparison Between Groups of Final Mean Scores ...................... 22

## List of Figures

- I Learning Curve for No Practice, Physical Practice and Mental Practice .......... 24
CHAPTER I

STATEMENT OF THE PROBLEM

The problem is twofold. First, it is to determine if mental practice will cause an increase in muscular endurance. Second, it is to discover if mental practice is as effective as physical practice in increasing muscular endurance. The test item selected to examine these hypotheses is sit-ups.
CHAPTER II

JUSTIFICATION OF THE PROBLEM

Within the field of physical education, and athletics in general, there has always been concern for the large amount of practice which is required for improvement in an activity. It has generally been accepted that improvement comes only from hours of physical practice and an unspecified amount of concentration. Although widely accepted as a fact, this procedure has never really been experimentally substantiated. Similarly, practice solely by a mental rehearsal or reminiscence has never been tested in the practical situation. However, a few experiments on mental practice in the acquisition of motor skills have been conducted in the laboratory.

Studies made by Vandell, Davis and Clugston (1), and Twining (2), revealed that mental practice, in place of the physical, results in a significant amount of improvement in the learning of certain motor skills such as dart throwing, basketball free throw and ring toss. Similar results were obtained by Steel (3) in an experiment involving accuracy in ball throwing. It is also reported by Karpovich and Hale (4) that improvement in running has been achieved through reminiscence of a warm-up before running. In all of these studies but the latter, which is not fully reported, the reliability of the test item could be questioned, as could the method of
controlling variables in the groups practising mentally. For instance, an equal amount of time is not spent by the groups practising mentally and physically, nor is there any method of determining whether the "mental" group was reminiscing or concentrating on the particular item tested. The present study attempts to establish closer controls on the group selected to practise mentally.

Rather than follow the motor skills area studied by previous authors a new aspect of muscular activity was chosen, namely, muscular endurance. Apparently, there have been no experimental studies made on the effect of mental practice versus physical practice in this area.

This study attempts to determine if there is a statistically significant improvement in performance within the area of muscular endurance, through mental practice of that item. Performance is also compared to that of a group practising physically and a group which does not practise in any manner.
REFERENCES


Vandell, Davis and Clugston (1) ran three separate experiments using dart throwing as the motor skill practised in two of them and a standard basketball free throw in the third. Each group of twelve boys was equated into three subgroups (2, p. 244) with respect to "intelligence, motor ability, educational age and physique". Group I practised the particular motor skill on the first and twentieth days; Group II on each of twenty days; Group III on the first and twentieth days with 30 minutes of mental practice from the second day to the nineteenth day inclusive. On the twentieth or final day all three groups repeated the test given on the first day.

The first experiment was carried out with junior high school boys throwing twenty-five darts at a two foot target from a distance of seventeen feet. The second experiment was done with senior high school boys throwing a basketball thirty-five times from the free throw line, while the third experiment involved college freshmen throwing twenty-five darts at a target similar in size and distance to the target used by the junior high school group. The mental practice of Group II in the three experiments took thirty minutes. This consisted of a mental rehearsal of the particular activity.
The results of the study showed that high school boys shooting basketball free throws improved two per cent (2%) under condition one, forty-one per cent (41%) under condition two, and forty-three per cent (43%) under condition three. The junior high school boys throwing darts improved minus two per cent (-2%) under condition one, plus seven per cent (7%) under condition two, and four per cent (4%) under condition three. College freshmen made no improvement under condition one, twenty-three per cent (23%) improvement under condition two, and twenty-two per cent (22%) improvement under condition three.

A study made in 1948 by Twining (3) generally followed the procedure established by Vandell, Davis and Clugston. In Twining's experiment, however, a ring toss was substituted for the dart throw and basketball free throw, one experiment only was run for twenty-two days, and mental practice was carried on for only fifteen minutes. This consisted of a rehearsal mentally of the ring toss.

Results from this experiment showed four and three tenths per cent (4.3%) improvement by the group having no practice, one hundred and thirty-seven and three tenths and three tenths per cent (137.3%) by the group practising physically, and thirty-six and two tenths per cent (36.2%) by the group practising mentally.
Apparently unaware of Twining's experiment, Steel conducted a similar experiment to that of Twining's in 1952 in England. However, Steel used a baseball throw for accuracy in place of Twining's ring toss, and the "mental" group practised for only ten minutes on each of ten days. Forty-five high school boys were tested on the first day and the eleventh day. Each boy stood at a distance of fifteen feet from a target of five concentric circles, with its centre four feet from the floor. Each circle was given a numerical value ranging from five to one, in diminishing order from centre to outer circle. Twenty-five balls were thrown by each subject and the total score represented his test score. Findings reveal that the group receiving no practice improved seven and six tenths per cent (7.6%), the group practising physically improved fifteen and three tenths per cent (15.3%) and the group practising mentally improved eleven and nine tenths per cent (11.9%).

According to Steel, the reliability of a test such as this is $0.85 \pm 0.02$. This claim is questionable, however, on the basis of Larson's and Yocum's (5, p. 163) evaluation of certain tests. The authors claimed that almost any skill test which involves an element of accuracy is usually only slightly reliable. More specifically, they found that the baseball throw for accuracy had a reliability coefficient below 0.80 which is, according to their classification, low.
From the results of these experiments it was concluded by Steel, Twining, Vandell, Davis and Clugston that mental practice is significant in the learning of a motor skill.

Karpovich and Hale (6) have reported that Malarecki has shown that running time in a 60 metre race improved when a subject thought about performing warm-ups before a race rather than performing them physically. However, information on this study is incomplete, and therefore, cannot be considered conclusive.

Related Studies

A. Motor Learning

As early as 1931 Freeman (7) studied experimentally the spread of neuro-muscular activity during mental work. By photographic studies of the thickening of muscles he was able to establish that there is a definite spread of neuro-muscular activity during mental work. Variations occur accompanying different sets and attitudes. It was also found that the amount of spread is a function of the set, and that under practice general neuro-muscular activity is reduced as the pattern becomes more specifically localized. Buegel (8) claims, on the other hand, that it seems to take longer to learn a motor pattern when ideational elements have been reduced to a minimum. However, he feels that (9, p. 117) the "introduction of ideational elements...facilitates learning at least in the early stages of the learning process".
For the purposes of the present study Freeman's evidence was accepted that spread occurs from the central nervous system to the muscles to be moved, and that, although this spread diminishes with concentration, increase in work output accompanies concentration.

B. Endurance

At the time of this study it has not been decided emphatically whether the test item selected (sit-ups) is one of muscular strength or muscular endurance. Authorities argue from both standpoints, but generally have little scientific or experimental evidence to support their views. A conclusion, however, has been reached for purposes of this study on the basis of the following comments and studies.

In 1946 Wedemeyer (10) conducted a study to determine the relationship between sit-ups and such factors as sit-up strength, endurance and weight. He concluded that (11, p. 46):

(a) there was no significant relationship between sit-ups and sit-up strength and weight,

(b) body build evidently does not have any important bearing on the sit-ups as a test of strength and endurance,

(c) after sit-up strength reached a certain level, further improvement in the number of sit-ups was accompanied by no significant increases in strength, and,

(d) the endurance factor appeared to improve more than did strength.
DeLorme (12) differentiates between muscular strength and muscular endurance on a different basis. After experimentation with exercises other than sit-ups, he states that (13, p. 64-9) "low repetition, high resistance exercises produce power (strength) and, high repetition low resistance exercises produce endurance". He also claims that power-building exercises and endurance-building exercises are two entirely different types, each one producing its own results, and each being wholly incapable of producing the results obtained by the other. Succinctly, he says (14, p. 651),

A muscle exercised solely on power-building exercises will not have the quality of endurance, whereas a muscle subjected exclusively to endurance-building exercises will not have the quality of power. However, a powerful muscle can be given endurance-building exercises and attain the quality of endurance; likewise, a muscle with great endurance can attain power through the power-building exercises.

Capen (15) used both aspects of DeLorme's information in a comparative study of three methods of sit-up training. He considers that practising either two minute, total number, or total number with a weight behind the head in preparation for a test involving the total number of sit-ups would give nearly equal results.

DeWitt (16) conducted a study to determine the degree to which different tests of the sit-up type correlate with criteria of abdominal muscle strength and endurance. He found that sit-ups without having the ankles held, sit-ups
with a slow lowering of the trunk until the head touched the floor, and sit-ups with ankles held for a two-minute test were all only slightly positively correlated with the criterion of endurance. This criterion, however, was a test in which the abdominal muscles were in a continuous state of contraction, while the test items involved alternate stages of contraction and relaxation.

Moreover, it has been suggested by McCloy (17) that, as far as endurance tests such as sit-ups are concerned, they are strongly influenced by strength only at the lower levels, and that they are primarily measures of muscular endurance.

In addition to these various views on sit-ups being measures of muscular strength or endurance there have been devised several standard tests for measuring sit-up achievement. These are the total number (18), one-, two-, three- or five-minute sit-ups for speed (19).

Definitions

Because only individuals were selected who were able to perform a minimum of twenty sit-ups, which fall within one negative standard deviation of the mean for students of this university (20), sit-ups are classed as an item of muscular endurance. The "total number of sit-ups" was selected for test purposes because the result of this test is a true indication of the extent to which the individual can continue re-
peated contractions and combat fatigue. It also satisfies the criterion of a muscular endurance test. This criterion involves the use of specific muscles (abdominal and thigh flexors) which are in alternate stages of contraction and relaxation and are carried to the point of exhaustion, whether the exercise is short and violent or long and gruelling (21, p. 600). In addition, it eliminates the factor of speed as a measure of endurance. Some individuals may be able to perform more effectively with slow rhythmic muscular contractions than with quick jerky movements.

For practice periods the five-minute sit-up test was used. It was necessary to establish a time limit for physical practice so that it would be comparable to time spent practising mentally. A one-, two-, or three-minute period was not considered long enough for either the group practising mentally or the group practising physically. Consequently, a five-minute practice period was used for both groups.

Finally, on the basis of the preceding discussion and experimental results, endurance was defined as the ability to continue repeated muscular activity.
REFERENCES


2. Vandell, Davis, Clugston, loc. cit.


CHAPTER IV

METHODS AND PROCEDURE

Four activity classes of the required physical education programme at The University of British Columbia were selected at random for the purpose of choosing students to participate in the experiment. All students within these classes were given a "total number of sit-ups" test which is moderately to highly reliable (.80-.89), according to Larson and Yocum (1, p. 163).

Directions for the "total number of sit-ups" test are standardized (2) and read as follows:

(a) start from the supine position;
(b) hold feet 12 inches apart firmly to the floor;
(c) lace fingers together behind the head;
(d) start on command, and alternate touching right elbows to left knee and left elbow to right knee;
(e) touch both shoulder blades to floor before each sit-up.
(f) maintain continuous motion at student's own speed.
(g) stop only when the next sit-up cannot be completed after a five second pulling attempt.

The subject then recorded his own score. A demonstration of the correct procedure was given after the directions were read to the students.
All students were retested one week later at the same time and under similar conditions such as lighting, place and atmosphere.

Thirty-six students were then selected by the "matching by pairs" technique to engage in the experiment (3, p. 228). The following example illustrates this method. Three students each performed thirty sit-ups on the initial test and thirty-four on the second test: each of these boys was placed in a separate group. This system of selection was used until three groups of twelve were obtained. Assigning of individuals to groups was done on a basis of catalogued random selection (4, p. 204).

Although a certain degree of "intelligence" is demanded for the mental rehearsal of sit-ups, there was no attempt to classify students on this factor because there appears to be only a very low positive correlation between intelligence and ability to learn a motor act (5, 6).

The groups were classified according to the condition under which they practised the tests.

Condition I: 12 boys: on the 1st and 22nd day;
Condition II: 12 boys: on the 1st and 22nd day with five minutes on each day from 2nd through 21st day physically rehearsing the first day's activities;
Condition III: 12 boys: on the 1st and 22nd day with
five minutes on each day from 2nd through
21st day mentally rehearsing the first
day's activities.

Results of the retest were used as scores for prac­
tice day number one because influence of the experimental
variable, i.e., mental or physical practice, did not begin un­
til after the retest.

After completing the retest, individuals of Condition
I were told that they did not need to return until the twenty­
second day when they were to repeat the test. They were asked
not to think about, discuss, watch or practise the item in the
meantime.

Boys under Condition II and III practised at the
same time of day, between 12:30 and 1:00 p.m. Condition II
students practised in a lecture room five days a week Monday
through Friday for four weeks. They were told to perform as
many sit-ups as possible within a five-minute period, record
their own results daily and leave them with the observer (cf.
Appendix B, p. 41). The individuals practising under Con­
dition II were also told that the practice was intended to im­
prove their performance, and they should, therefore, strive to
increase the number which they could do within a five-minute
period.
It is important to note at this point that none of the groups was told the nature of the study, the entire purpose of the practice or the existence of other groups. This procedure was followed to eliminate competition between groups and to control each group as closely as possible under the conditions of the experiment.

Individuals practising under Condition III practised in a lecture room five days a week Monday through Friday for four weeks. They were given the following directions:

You are to rehearse mentally the first day's activity in an attempt to improve your performance. Concentrate on nothing other than the particular item selected. You are to spend five minutes mentally practising the item, and you may devise and attempt new techniques mentally in an effort to increase the number of sit-ups which you can do within five minutes. If and when reading material on the topic is provided in this room, you may consult it. Moreover, at the 4-1/2 minute mark you will be given 30 seconds in which to write a very short sentence on a sheet provided for this purpose (cf. Appendix C, p. 42). In this sentence you are to state either how you are performing the test item, what other ways you have thought of, how many you have mentally done, or are attempting to do, etc., and answer one question given daily (cf. Appendix D, p. 43). At the end of five minutes you may leave.

At the end of twenty-one days trials ceased. On the twenty-second day individuals from all three groups were given the original test, with individuals again recording their results on a master score sheet. This final test was taken at the same time of day as the original test was taken, in the same setting with similar conditions.
REFERENCES


CHAPTER V

RESULTS

Thirty-six first and second year students were presented with a muscular endurance experiment consisting of sit-ups. After a test and retest they were selected by the "matching by pairs" technique and were divided into three groups of twelve per group on the basis of catalogued random sampling. One group did not practise again for twenty days. Another group had physical practice performing sit-ups for twenty days. A third group mentally rehearsed the endurance item for twenty days. On the twenty-second day all subjects who had not dropped out repeated the original sit-up test.

Imperovement was measured within groups and a comparison of this improvement was made between groups. Gain was measured by the difference in mean scores between practice day 1 and practice day 22.

Raw scores for day 22, which indicate individual variations, are shown in Table I.
TABLE I

Final Test Scores of Matched Subjects in the Equated Groups

<table>
<thead>
<tr>
<th>Subject</th>
<th>Control Group</th>
<th>Physical Group</th>
<th>Mental Group</th>
</tr>
</thead>
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<tr>
<td>1</td>
<td>35</td>
<td>101</td>
<td>71</td>
</tr>
<tr>
<td>2</td>
<td>36</td>
<td>153</td>
<td>43</td>
</tr>
<tr>
<td>3</td>
<td>32</td>
<td>350</td>
<td>45</td>
</tr>
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<td>4</td>
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<td>123</td>
<td>44</td>
</tr>
<tr>
<td>6</td>
<td>20</td>
<td>48</td>
<td>21</td>
</tr>
<tr>
<td>7</td>
<td>36</td>
<td>159</td>
<td>50</td>
</tr>
<tr>
<td>8</td>
<td>58</td>
<td>145</td>
<td>45</td>
</tr>
</tbody>
</table>

In Table II the increase in endurance is shown. The \( ^* \) technique was used to determine the critical ratio.

TABLE II

Improvement in Endurance Due to Practice

<p>| Number of | Prac- | Mean | SD | Mean | SD | Percent C.R. | Improve- |
| Sub- | Mea- | SD | 22nd | 22nd | ment | Ratio |</p>
<table>
<thead>
<tr>
<th>jects</th>
<th>nes</th>
<th>Day</th>
<th>Day</th>
<th>Day</th>
<th>Day</th>
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<td></td>
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<td>Day</td>
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<td>Day</td>
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<td></td>
<td>ods</td>
<td>Score</td>
<td>Score</td>
<td>Score</td>
<td>Score</td>
<td></td>
</tr>
<tr>
<td>CI</td>
<td>8</td>
<td>2</td>
<td>34.86</td>
<td>6.22</td>
<td>37.88</td>
<td>10.84</td>
</tr>
<tr>
<td>CII</td>
<td>8</td>
<td>22</td>
<td>34.86</td>
<td>6.22</td>
<td>47.38</td>
<td>89.52</td>
</tr>
<tr>
<td>CIII</td>
<td>8</td>
<td>22</td>
<td>34.86</td>
<td>6.22</td>
<td>45.00</td>
<td>13.62</td>
</tr>
</tbody>
</table>

\( ^* \) Significant at 0.01 level of confidence
\( ^* \) Significant at 0.05 level of confidence
Condition I (no practice)
Condition II (physical practice)
Condition III (mental practice)
Condition I (no practice) resulted in little increase. The subjects improved 8.7 per cent, which is not statistically significant since the \( t \) ratio is only 1.24. The ratio is typical of chance effects only (cf. Appendix A, p. ). Condition II (physical practice) resulted in 322.8 per cent gain, or an average increase of 112.52 sit-ups, which is significant at the 0.01 level of confidence. Condition III (mental practice) resulted in 29.1 per cent improvement or an average increase of 10.14 sit-ups, which is significant at the 0.05 level of confidence.

Comparison of improvement was made between groups by measuring the difference between mean scores of day 22, as shown in Table III.

**TABLE III**

<table>
<thead>
<tr>
<th></th>
<th>Mean 22nd Day Score</th>
<th>SD 22nd Day Score</th>
<th>( t ) Ratio</th>
<th>df</th>
</tr>
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<tbody>
<tr>
<td>Physical Practice</td>
<td>147.38</td>
<td>89.52</td>
<td>3.44</td>
<td>7</td>
</tr>
<tr>
<td>Versus Control</td>
<td>37.88</td>
<td>10.84</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mental Practice</td>
<td>45.00</td>
<td>13.62</td>
<td>1.39</td>
<td>7</td>
</tr>
<tr>
<td>Versus Control</td>
<td>37.88</td>
<td>10.84</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical Practice</td>
<td>147.38</td>
<td>89.52</td>
<td>3.14</td>
<td>7</td>
</tr>
<tr>
<td>Versus Mental Practice</td>
<td>45.00</td>
<td>13.62</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Determined by the "matching by pairs" technique results showed that the difference between Condition I (no prac-
practice) and Condition II (physical practice) was highly significant with a ± ratio favoring Condition II (physical practice). The difference between Condition II and Condition III (mental practice) was also significant in favor of Condition II (physical practice) with a ± ratio of 3.14. The difference between Condition I and Condition III, however, was not statistically significant since the ± ratio was only 1.39. The wide variations in improvement between groups is graphically portrayed in Figure 1, page 24.
From day 2 to day 21 inclusive practice was for 5 minutes. On day 1 and day 22 sit-ups were performed on an unlimited time basis for subjects under all three Conditions.
CHAPTER VI

DISCUSSION

It would appear that mental and physical practice are both means of facilitating an increase in muscular endurance. The relative value between mental and physical practice in muscular endurance, however, is not easily defined as to the amount of time which should be spent on each method of practice. From the results, as shown in Table II, page 21, and Table III, page 22, a combination of the two elements of practice appears desirable. Emphasis, however, should be on the physical.

It is perhaps to be expected that muscular endurance would be increased by mental practice to an extent somewhere between that achieved through actual physical repetition and that attained through no practice. As Steel states (1, p. 101), "the effects of reminiscence, the integrating activity of the brain's structure, would suggest that an increase would be the most probable result to expect (even) where no practice occurs". In mental practice, concentration assists the integrative action of the central nervous system even more so, besides sending impulses more frequently to the musculature. To an unspecified limit more impulses result in more contractions. According to Wakim, however, (2, p. 106), in the generally unexercised muscle the onset of fatigue will
occur more rapidly than in the exercised muscle because of a combination of exhaustion of acetylcholine of the myoneural junction and an inability of the circulatory system to supply oxygen and to rapidly remove waste products, especially lactic acid, from the exercised muscles.

Conversely, the increase in endurance of the physical practice subjects is probably due to the increased ability of their bodily systems to exchange nutrients and waste materials efficiently, as well as increasing the ability of the nervous mechanism to transmit impulses to the muscle fibers.

The physiological processes (which may account for the significant difference in improvement of the physical group over the control and the mental groups) are best summed up by Hemingway. He says (3, p. 71),

*With repetitive stimulation, at a sufficiently high frequency, there is a decrement in response. As to the mechanism of this there is, as yet, no clear explanation. But the experiments of other workers who have examined the effects of anoxia of spinal reflexes under similar conditions show a parallel which may be significant.*

*The extent to which the effects induced by anoxia resemble those of fatigue may be a matter of opinion, but it is certain that in many circumstances they are identical, and that curtailment of oxygen supply promotes the onset of fatigue at an earlier time than would otherwise occur.*

*It seems possible, therefore, that many of the signs and symptoms of fatigue in the neuromuscular system might be explained in terms of anoxia and the failure to strike a balance between the processes responsible for the conduction and transmission of the nerve impulses and the supply of oxygen necessary to maintain the chemical processes concerned in the maintenance of the nervous mechanisms.*
Other factors were present, however, which tended to enhance the difference.

1. During the experiment the physical practice group (Condition II) was able to observe the gradual improvement in their scores. Each day provided a challenge to improve over the score of the preceding day. Moreover, knowledge of other group members' scores provided an added stimulus for improvement. Interest became keener as the experiment progressed and various techniques were tested, e.g., holding the breath while raising the trunk, holding the breath while lowering, closing the eyes and developing a kinesthetic sense or rhythm, racing through the test item or performing it slowly, methodically or rhythmically.

2. Opposed to this practical experimentation and knowledge of progress was the lack of similar stimulation for the mental practice group. They, of course, did not plot their progress in the same manner as the physical practice group; not until the end of the experiment did they see the results of their practice. Interest, however, was comparable to that of the physical practice group. This was evident by replies to the question, "Is the mental rehearsal of sit-ups becoming tedious or boring?" Some of the replies were as follows:

(a) "I'm interested,...in knowing exactly how many (sit-ups), when tested, that I can do."

(b) "I'm getting a higher number of sit-ups every day and I'm anxious to see if this will work."
(c) "I would like to try it today. I wonder if I could do 1000 or go to true physical fatigue. Why not?"

3. Except for the final 30 seconds the mental practice period was spent mentally rehearsing the test item of sit-ups. According to questionnaire replies, various techniques were attempted by everyone. The mental group was at a disadvantage in the testing of these techniques. Although the form of the item was generally uniform for all subjects, e.g., hands interlaced behind neck, partner holding ankles 12" apart, etc., certain variations in pace, breathing and method of count could not be adopted. Subjects of the physical practice group had an opportunity to experiment with variations to arrive at a style suited to them well in advance of the final test. On the contrary, the mental practice group had to test their technique on the final day, which gave them little opportunity to perfect a technique. This would tend to favor improvement in the scores of subjects under Condition II (physical practice).


CHAPTER VII

SUMMARY AND CONCLUSIONS

Thirty-six first and second year university students were presented with a muscular endurance experiment consisting of sit-ups. After a test and retest they were selected by the "matching by pairs" technique and were divided into three groups on the basis of catalogued random sampling. One group did not practise any more for twenty days. Another group had physical practice performing sit-ups for twenty days. A third group mentally rehearsed the endurance item for twenty days. On the twenty-second day twenty-four subjects repeated the original test. Twelve of the original thirty-six subjects either dropped out or had to be excluded because of no matched pair.

Subjects receiving no practice showed no significant improvement in muscular endurance. The group receiving physical practice improved 322 per cent or increased on an average of 112.52 sit-ups and the group receiving mental practice improved 29 per cent or 10.14 sit-ups. In both of these groups the improvement was statistically significant at the 0.01 and 0.05 level of confidence respectively.

There were significant differences in mean final scores between physical practice and no practice, and between physical practice and mental practice. In both instances the
significant difference was in favor of physical practice. There was no significant difference between mental practice and no practice.

It is concluded that both physical and mental practice, under the conditions of the experiment, are effective in increasing muscular endurance. The degree of increase with respect to mental practice, however, is not sufficiently large enough to advocate its use exclusive of physical practice where physical practice is possible. Physical practice is a much more effective means of increasing muscular endurance than mental practice.

It is recommended that further studies in this area deal with the following problems.

1. In practice which utilizes a combination of mental and physical practice what should be the ratio between time spent on physical practice and that spent on mental practice?

2. Can performance be improved as much through physical practice as through a combination of physical and mental practice?
BIBLIOGRAPHY

BOOKS


The Iowa Program of Physical Education for Boys, Des Moines, Department of Public Instruction, 1945.


BOOKS (cont'd)


PERIODICALS


PERIODICALS (cont'd)


PERIODICALS (cont'd)


PERIODICALS (cont'd)


The following statistical procedures were used to analyze results of this experiment.

1. Significance of Difference Between Correlated Means Obtained From the Same Test Administered to the Same Group Upon Two Occasions

To determine the significance of the difference between the means of the retest and the final test within each of the three groups the $t$ ratio was obtained. Level of confidence was required to reach 0.05 to be acceptable. To obtain the significance the following formulae were used:

\[
M = \frac{\bar{x}}{N}
\]

\[
\sigma = SD = \sqrt{\frac{\sum x^2}{N - 1}}
\]

\[
\sigma_M = SD_M = \frac{\sigma}{\sqrt{N}}
\]

\[
r = \frac{N \bar{x} \bar{y} - \bar{x} \bar{y}}{\sqrt{[N x^2 - (x)^2][N y^2 - (y)^2]}}
\]

\[
\delta_D = SE_D = \sqrt{\delta_M^2 + \delta_M^2 - 2r \frac{\delta_M \delta_M}{2}}
\]

\[
t = \frac{M_1 - M_2}{SE_D}
\]

2. Significance of Difference of Means of Final Scores Between Equivalent Groups

To determine the significance of difference between
the means of final scores for each of three groups the \( t \)-ratio was also used. Garrett (1, p. 228) explains this procedure as follows:

The formula  

\[ SE_D = \sqrt{\frac{\sigma^2}{M_1} + \frac{\sigma^2}{M_2} - \frac{2r_{12}}{\sigma_M^2}} \]

is applicable in those experiments which make use of equivalent groups as well as those using a single group. In the method of equivalent groups the matching is done initially by pairs so that each person in the first group has a match in the second group. This procedure enables us to set off the effects of one or more experimentally varied conditions (experimental factors) against the absence of these same variables (control).

Data required for the calculation included:

- Number in each group
- Mean scores for both groups compared
- \( S_D \)'s for both groups
- \( S_{DM} \)'s for both groups, final test
- Difference between means \((M_1 - M_2)\)
- Correlation between final scores of both groups \( \sigma_D \) or \( S_D \)
- \( t \)-ratio

Table of \( t \), for use in determining the significance of the differences between means.

In this section or analysis the mean of final scores of Group II was compared to that of Group I; mean of final scores of Group III to that of Group I; mean of final scores of Group II to that of Group III. Significance of difference was acceptable at the 0.05 level of confidence.
The table of $t$ at both the 0.05 and 0.01 level of confidence for seven degrees of freedom (8-1) is shown below (2, p. 449).

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<tr>
<th>Degrees of Freedom</th>
<th>Probability</th>
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<tr>
<td></td>
<td>$+ = 3.50$</td>
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</table>

REFERENCES


APPENDIX B

INDIVIDUAL SCORE SHEET

GROUP I, II or III

| NAME |
| ADDRESS |
| PHONE NO. |
| AGE |

<table>
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<tr>
<th>Day</th>
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<th>3</th>
<th>4</th>
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</table>
APPENDIX C

BLANK SHEET FOR RECORDING THOUGHTS OF GROUP III

NAME _____________________________ DATE __________

DAY __________

__________________________

ANSWER DAILY QUESTION BELOW THIS LINE
APPENDIX D

DAILY QUESTIONS FOR GROUP III

One question will be given each day in the order presented here. The question is answered prior to the sentence which is written to describe the individual's thinking during the preceding 4-1/2 minutes.

1. Name two different positions for your feet while doing sit-ups.
2. Name two positions in which your hands may be placed while doing sit-ups.
3. What is the total number of sit-ups you were able to perform mentally today?
4. Does a mental rehearsal of this item give you the feeling of physical exhaustion?
5. Have you found it mentally easier to perform the sit-ups while a partner theoretically holds your ankles?
6. Do you keep your eyes open or closed while concentrating?
7. How many different sit-up techniques have you used in your mental rehearsals? Name them.
8. How many sit-ups do you believe you could perform physically if the test was repeated at this stage of the experiment?
9. Is there an increase in the number of sit-ups you can perform when you concentrate with your eyes open?
10. Is there any one particular area of your body which experiences a working sensation while mentally rehearsing sit-ups? If so, what area?
11. Apparently one of the factors which influences muscular work is the number of muscle fibers which are utilized during work. If this number can be increased by stimulation through a nerve, do you think that you can increase your work output by sending more impulses to the muscles through the higher central nervous system or brain?

12. Is the mental rehearsal of sit-ups becoming tedious or boring?

13. At this stage of your rehearsal how many sit-ups do you think you could perform physically?

14. If you were given the opportunity to perform the sit-ups physically with a different technique to the one used initially, do you believe that you could improve your performance? If so, what technique would you use?

15. Do you set a limit each day on the number of sit-ups which you perform mentally? If so, how do you determine this limit?

16. If given the opportunity to use a different technique to the one used initially, would you use a different one?

17. Are you able to concentrate on the test item to a lesser, similar or greater extent than in the first few days of the experiment.

18. Do you picture yourself performing the sit-ups in any particular place, i.e., do you think of doing them in this room, on the gymnasium floor, at home, etc., or do you practise them abstractly?
19. How many sit-ups were you able to perform mentally today?
20. What is the number of sit-ups which you have set as a minimum for the final physical test?
APPENDIX E

RAW SCORES FOR CONDITION I (NO PRACTICE)

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<tr>
<th>Subject Number</th>
<th>Number of Sit-ups on Selection Test</th>
<th>Number of Sit-ups Day 1</th>
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Unlimited time with no rest periods
## APPENDIX F

### DAILY RAW SCORES AND AVERAGES FOR CONDITION II (PHYSICAL PRACTICE)

#### Daily Scores - Total Number of Sit-ups on Day Number:

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**TOTALS** 279 408 481 535 510 479 581 555 581 726 661 741 685 681 701 713 610 862 729 791 723 1179

**AVERAGE** 34.86 60.12 72.86 83.0 83.0 95.29 97.86 100.14 101.67 104.14 103.29 51.0 66.88 79.83 79.29 91.0 92.65 97.29 101.86 107.75 113.0 147.38

*Days 2 to 21 Inclusive - 5 minute limit for practice with unlimited number of rests permitted*

*Day 1 and 22 - Unlimited time with no rest periods*
APPENDIX G

RAW SCORES FOR CONDITION III (MENTAL PRACTICE)

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<tr>
<th>Subject Number</th>
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Unlimited time with no rest periods