VARIATIONS IN THE EFFECTS OF 
TWO TRAINING METHODS UPON WORK OUTPUT

by

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April, 1963
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Date April 1963.
ABSTRACT

The purpose of this study was to determine the effect of "steady pace" and "interval" training methods upon work output.

Thirty-four male University of British Columbia first year students between the ages of nineteen and twenty-one, were selected from the required physical education activity program. Each student was tested on a fixed resistance type bicycle ergometer. The number of revolutions achieved in two minutes was recorded. Two groups were then formed by the "paired comparison" method and trained for six weeks. Both groups did the same amount of work in each training session but each group varied its method of work application, i.e. one group trained at a steady effort while the other group trained at a higher power, with regulated rest periods between bursts of power. Each group was subjected to a two minute test at the intervals of two, four and six weeks after the commencement of training.

On the basis of statistical treatment, the following results were evident:

1. There was no statistically significant improvement of work output scores for either group after two weeks of training.

2. After four weeks of training, both groups exhibited marked improvement in work output scores which were statistically significant at the five percent level of confidence.

3. Tests after six weeks of training indicated statistically significant improvements in performance scores in both groups. These scores were statistically significant at the five percent level of confidence.

4. Both types of training, when compared, showed no difference in the results obtained at the end of two, four and six weeks of training.
There was no statistically significant difference between the means of each group at the end of two, four and six weeks of regulated training.

It was concluded that within the limitations of the study, there was no difference in work output obtained from the results of either "steady" or "interval" types of training provided the total work done by the members of either group was the same. In both groups, however, a statistically significant gain in work output was evident after four and six weeks of training.
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CHAPTER I

STATEMENT OF THE PROBLEM

There have been varying reports during recent years, upon the effectiveness of "constant speed" training and "interval" training upon athletes. This has been especially so in training for middle distance events in track. Champions have resulted from both methods. "Constant speed" training is defined herein as work at a constant pace over a set period of time. "Interval" training is defined herein as a number of equal work efforts of shorter duration than the "Constant speed" type, done at a faster pace.

This study is aimed at determining the effect upon work output of (a) "constant speed" and (b) "interval" training methods, upon human subjects. Work output is determined by the amount of work the subject can do, over a timed ride upon a bicycle-type ergometer. The measurement of work output is carried out before and after a six week training period.
CHAPTER II

JUSTIFICATION OF THE PROBLEM

Modern training methods for middle distance running are almost as varied as the number of competitors. Many statements have been made claiming that "interval" training methods of under distance, with faster than race pace are superior to "constant speed" training. Doherty (1), Holmer (2) and Stampfl (3), all renowned middle distance coaches, recommend interval methods. Bresnahan and Tuttle (4) outline a method using constant speed and over distance. Bowerman (5) claims endurance is acquired through the "fartlek" type of activities. He says (6, p. 81): "Our fartlek activity includes striding at an easy pace until some fatigue begins to set in." Cerutty (7), to some extent also agrees with the application of steady over distance training methods to improve endurance.

Cureton (8) outlines that the best gains in cardio-vascular improvement have been achieved by repeated two hundred and twenty yard, four hundred and forty yard "run throughs", cross-country and steady pace over distance running. He does not outline which is the better system.

Very few studies have been published where controlled groups are used to determine the effects of interval and steady paced training upon work capacity. Sinisalo and Juurtola (9) in Finland, compared the physiological effects of two ski training methods. Here they used "constant speed" and "interval" training. They found the "interval" training improved the ability to cover the last stage of the race at an improved pace.
In this study an attempt has been made to determine the differences in work output of two groups of male students during a training period of six weeks. One group trained by the "interval" method of training; the other group did "constant speed" training. The work load for each training session was the same for each group. The same bicycle ergometer, set at a fixed resistance was used by both groups for all training and testing rides.
REFERENCES


CHAPTER III

REVIEW OF THE LITERATURE

The review of the literature is divided into two parts. One section reviews the studies related to the use of the bicycle ergometer. The other part reviews the studies related to the methods used in the determination of the effects of training upon work output.

(I) Studies related to the apparatus used in this study: viz., the bicycle ergometer.

The friction type resistance bicycle ergometer used in this study is of the type manufactured by J.A. Preston Corporation. Reference to it may be obtained in Appendix D. The functional workings of a bicycle ergometer and its construction are described by Dobelni (1) and Karpovich (2). Henry (3) used an ergometer set at 69 revolutions per minute with a 620 kg.m./min. load and a 95 kg.m./min. load at 116 revolutions per minute to study individual differences in oxygen metabolism of work at two speeds of movement. The subjects in Henry's study pedalled at standardized revolutions per minute with a fixed load for five minutes. Cogswell et al (4), in observing the effects of training upon pulse rate, blood pressure and endurance of humans, used a step test (Harvard), treadmill and an electro-dynamic brake bicycle ergometer. Cogswell's subjects pedalled for sixty seconds at a maximum load.

Henry and Demoor (5), in determining the metabolic efficiency of exercise in relation to work load at constant speed, used the bicycle ergometer and the closed circuit respiratory apparatus. Gemmill et al (6) in studies upon muscular training, used a bicycle ergometer as a method of training under controlled conditions. The bicycle ergometer was selected...
as the instrument for testing work output and for controlled training.

(II) Studies related to the methods used in determining the effects of training upon work output.

Many studies have reported the effects of training, but few have compared the effects of two specific training methods. Most studies have been interested in the physiological variations due to training rather than the direct result of improvement in work output. Such tests have been carried out by Cogswell et al (9) in determining the effects of a training period upon pulse rate, and blood pressure. In determining the physiological effects of daily repetition of the same amount of light muscular work, Gemmill (9) had subjects ride a bicycle ergometer for half an hour each day. Physiological data were obtained and recorded. The following changes were observed: an increase in the efficiency of the respiratory and cardio mechanisms, a faster return to normal pulse rate after exercise, a decrease in total ventilation, and no change in basal metabolism. Gemmill (10) again using two groups - seven track men and seven non-athletes - found training outdoors difficult to control and used a bicycle ergometer. Here again physiological factors were determined and it was found there was no change in gross or net respiratory quotient. The greater change being total ventilation increase.

Cureton (11) claims that two hundred and twenty yard and four hundred and forty yard interval training in track and long distance running are the best methods to improve endurance, but he does not indicate which method is superior.

Sinisalo and Juurtola (12), in Finland, in 1956, attempted to compare the physiological effects of two ski-training methods. Twenty subjects
were given ten physical tests at the beginning and at the end of an eight week ski-training period. Using the t-test, statistically significant differences between the first test and the second test in the total group of subjects were found in the following tests: breath holding, pulse rate on a bicycle ergometer, recovery pulse, floor push ups, full squat jumps, agility exercises, time of the skiing race, and the time of the last two kilometers in the skiing race. Statistically significant differences between the mean gains were found in breath holding and "spurt ability" in favour of the interval training group, and in floor push-ups in favour of the constant speed training group.

In order to establish a suitable test for the work capacity it was first noted that Riedman (13) gives the formula for work upon a bicycle ergometer as the weight of the resistance times the distance of rotation. Karpovich (14) states that endurance can be expressed in terms of how many times one movement can be repeated. Gallagher and Brouha (14) claim:

To test dynamic fitness, which we define as the capacity to perform strenuous exercise and recover from it, the test itself must be strenuous. Whether a treadmill, an ergometer bicycle or the more simple step-test is used is not important as long as an exercise requiring no particular skill, utilizing the large muscle groups and gives the heart and lungs so much work to do that a "steady state" cannot be maintained.

Taylor et al (16) claim in a study of exercise tolerance that: the only defensible "a priori" criterion of fitness of a man for heavy physical exercise is the amount of work the man can do.

In considering the psychological considerations of exerting maximum work capacity, Henry and Berg (17) assumed:

Factors such as individual willingness to exert maximally and special aptitudes for
the muscular activity of the test tend to cancel out in a comparison of performance before and after conditioning, thus making it possible to demonstrate some improvement in physical fitness by this technique even though there may be only a small relationship between fitness and actual performance scores.

Larson (19) reviews cardiovascular respiratory function in relation to "physical fitness". Here he quotes Schneider (20):

...the equipment that enables a man to combat adverse influence is partly inborn and partly acquired. He classifies this equipment into three categories: the morphologic, the physiologic and psychologic. The morphologic consists of the physical form and structure determined largely by heredity and also by use. The physiologic are organs which by graded and frequent use yield capacity for adjustment in activity. The psychologic is the mind, the master of the body machine, which acquires greater capacity and adjustment with graded and proper use. The "fitness" of an individual is determined by all three, of which the cardiovascular tests only partially measure one — the physiologic and reflect the psychologic.
REFERENCES


CHAPTER IV

METHODS AND PROCEDURE

Determination of Work Output

Thirty-four males between the ages of nineteen and twenty-one were selected on a voluntary basis from the required Physical Education Program at the University of British Columbia. Persons who regularly rode a bicycle were not selected to participate in the study. The subjects were tested to determine the maximum work they could do upon a frictional type bicycle ergometer. An index of the amount of work done was recorded by the number of pedal revolutions achieved in a set time period with the resistance held constant.

The bicycle ergometer was of the frictional type manufactured by J.A. Preston Corporation and was fitted with a revolution counter and a variable resistance meter.

As suggested by Henry (1) each subject was allowed a practice session upon the bicycle ergometer to enable him to become skillfull upon this machinery. It is Henry's opinion (2, p. 15) that practice is required because: "There is some element of acquired skill in doing the work efficiently." The practice sessions were limited to a five minute period on Monday, Wednesday and Friday during the week preceding the testing for reliability of the subjects to perform the test items.

The bicycle ergometer was set at a fixed resistance of fourteen kilograms for all trials. This figure was chosen because it was near the resistance chosen by Henry and DeMoor (3) for "maximal" work. The subjects were tested upon the number of completed pedal revolutions they could achieve pedalling against the set resistance for two minutes.
Grouping

After the initial test, the subjects were ranked in the order of their performance and two groups selected by the "paired comparison" method as outlined by Garrett (4, p. 228). The reliability of subjects to perform the test item was determined by the test-retest method.

**GROUP A**

Test 1 (to equate)

Test 2 (reliability)

1st Two Weeks
Six minutes pedalling at 60 rev/min. constant speed at fixed resistance. Total revs. 360.

Test 3

2nd Two Weeks
Six minutes 36 secs. pedalling at 60 rev/min. constant speed at fixed resistance. Total revs. 396.

Test 4

3rd Two Weeks
Seven minutes 12 seconds pedalling at 60 rev/min. constant speed at fixed resistance. Total revs. 432.

**GROUP B**

1st Two Weeks
Pedalling for a minute at 60 rev/min. for six intervals. Total revs. 360.

2nd Two Weeks
66 rev/min. for 6 intervals at half minute duration. Total rev. 396.

3rd Two Weeks
72 rev/min. for 6 intervals at half minute duration. Total revs. 432.

* The "interval" training group rested for one minute between each effort.

**Figure 1. TRAINING SCHEDULE**

Training and Testing

One group used "constant speed" training and was called Group A. The other group used the "interval" training and was called Group B. Each group trained to a set pattern as outlined in Figure 1.

The "interval" training group rested for one minute between each effort. Training was tri-weekly for six weeks. Training took place on Monday, Wednesday and Friday of each week. During training, the subjects
regulated their pace by synchronizing the sound produced by a mechanical counter mounted on the bicycle-type ergometer, with the click of a metronome set at the required pattern. Work ceased when the total revolutions required at the stage of training was completed.

The subjects were retested for work output at the end of each two week period and the effects of training upon work output recorded. This was carried out on each alternate Friday. Training was forfeited on the test days. Thus, testing was carried out after every five training sessions. Any subject missing a regular session was disregarded along with his paired counterpart in the other training group. The subjects were not informed of their test score. At the end of six weeks training, twelve of the original pairs remained. These were used as the test subjects in this study.

All training and testing were completed under the supervision of the same instructor. Individual tests were conducted at the same time on each day. The following verbal instruction was given: "You are required to give your best performance in pedalling for two minutes. You will be told when intervals of thirty seconds, sixty seconds and ninety seconds occur. Start on - go! Finish on - stop!"

The scoring for each individual subject was kept on separate cards (c.f. Appendix B. p.3). These cards were filled out for necessary particulars by the instructor and filed until required.

Testing and training were administered indoors, on the same bicycle type ergometer, between early October and late November, 1960.


CHAPTER V

RESULTS

Reliability of Group Scores on the Test Item

The group reliability co-efficient computed between trials one and two, on the same test item, using the results of the twenty-four subjects who completed the training program was found to be $0.72 \pm 0.10$. This reliability co-efficient indicated a moderate amount of individual difference in the ability of the subjects to reproduce reliable results, using the two minute work output test upon the frictional-type bicycle ergometer. A reliability co-efficient of 0.72 suggested approximately fifty-two percent variance in common for individuals on both tests. The difficulty of obtaining a "high" reliability on the test item was probably due to the inability of untrained subjects to pace themselves upon the two minute test. Investigation of the half minute breakdown of test retest scores indicated differences in the methods of attempting the test item. For example, some subjects were better able to pace themselves on both tests, while others seemed unable to judge the pace. Due to the likelihood of intra-individual differences influencing the reliability of individuals to perform this type of endurance test, a reliability of $0.72 \pm 0.10$ was considered high enough to meet the purpose of this study.

Data were obtained from testing before training began and thence at two week intervals, until the completion of six weeks of training.

The data were treated statistically in two ways:

(a) Within Groups - The changes produced in each group, by the training method used by that group, were tested for statistical significance using Fisher's "t" statistic at the five percent level of confidence.
The following mean scores were compared: test 2 with tests 3, 4 and 5; test 3 with test 4; and test 4 with test 5.

(b) Between Groups - The superiority of one training method over another was tested for statistical significance using Fisher's "t" statistic at the five percent level of confidence. Here the mean scores of each group were compared test by test, i.e. test 1 - group A with test 1 group B; test 2 group A with test 2 group B; test 3 group A with test 3 group B; test 4 group A with test 4 group B; test 5 group A with test 5 group B.

The Results of the Work Output Tests of Group A - The "Steady" Training Group

The differences in mean performance levels between tests were shown in Table I. No statistically significant improvement in the mean scores of the group was shown at the five percent level of confidence, after two weeks of training. Thus, any difference occurring between the means was attributed to chance.

After four weeks of training, the mean of the group showed an increase in work output, statistically significant at the five percent level of confidence. The mean performance showed an increase of 23.3 revolutions above the initial work output test. Eleven subjects gave an increased score. One subject's score decreased.
TABLE 1
A Comparison of the Significance of Mean Performance Scores of the "Steady" Training Group Between Tests 2 & 3; Tests 3 & 4; Tests 4 & 5; Tests 2 & 4; and Tests 2 & 5.

<table>
<thead>
<tr>
<th>Test Interval</th>
<th>Initial Test</th>
<th>Final Test</th>
<th>Difference Between Means</th>
<th>Standard Error Between Means</th>
<th>&quot;t&quot; Test of Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 2-Test 3</td>
<td>200.0</td>
<td>198.3</td>
<td>-1.7</td>
<td>7.6</td>
<td>0.2</td>
</tr>
<tr>
<td>Test 2-Test 4</td>
<td>200.0</td>
<td>223.3</td>
<td>23.3</td>
<td>5.8</td>
<td>4.0</td>
</tr>
<tr>
<td>Test 2-Test 5</td>
<td>200.0</td>
<td>229.0</td>
<td>29.0</td>
<td>5.2</td>
<td>5.6</td>
</tr>
<tr>
<td>Test 3-Test 4</td>
<td>198.3</td>
<td>223.3</td>
<td>25.0</td>
<td>6.4</td>
<td>3.9</td>
</tr>
<tr>
<td>Test 4-Test 5</td>
<td>223.3</td>
<td>229.0</td>
<td>5.7</td>
<td>5.5</td>
<td>1.0</td>
</tr>
</tbody>
</table>

For 11 degrees of freedom a t of 2.20 is significant at the 5 percent level of confidence.
The Results of the Work Output Tests of Group B - The "Interval" Training Group

The differences in the mean performance levels between tests were shown in Table 2.

This group showed no statistically significant difference at the five percent level of confidence, in mean performance scores as a result of the first two weeks of training. This result was similar to results obtained by the "steady" training group for the same period of training. Any differences in the mean performance scores could only be attributed to chance.

The mean scores of work output at the end of four weeks of training showed a statistically significant improvement at the five percent level of confidence. The mean performance was 27.5 revolutions greater than at the onset of training. Eleven of the twelve subjects exhibited improved scores.

After six weeks of training, this group showed a mean improvement of 29 revolutions over the mean score at the commencement of training. This improvement was statistically significant at the five percent level of confidence. All subjects gave an increased performance score.

An increase in the mean work output scores between tests at the end of week two and week four was statistically significant at the five percent level of confidence. At the end of four weeks of training, the mean increase was 22.7 revolutions above the mean score at the end of week two.

The difference between the mean score at the end of four weeks and the mean performance obtained at the end of six weeks was not statistically significant at the five percent level of confidence.
At the completion of six weeks of training, the mean performance of the group indicated an improvement in work output. This improvement was statistically significant at the five percent level of confidence. The mean performance score at the end of six weeks was 29 revolutions greater than the initial score.

Between weeks two and four the increase in the mean performance scores was statistically significant at the five percent level of confidence. The mean performance score at the end of four weeks of training was 25 revolutions above the score obtained at the end of two weeks of training.

The increase in work output of the group, as indicated by the revolution scores on the test item, between tests at the end of four and six weeks was not statistically significant at the five percent level of confidence.
TABLE 2
A Comparison of the Significance of Mean Performance Scores of the "Interval" Training Group Between Tests 2 & 3; Tests 3 & 4; Tests 4 & 5; Tests 2 & 4; Tests 2 & 5.

<table>
<thead>
<tr>
<th>Test Interval</th>
<th>Initial Test M_1 SD_1</th>
<th>Final Test M_2 SD_2</th>
<th>Difference Between the Means M_2 - M_1</th>
<th>Standard Error of the Difference Between the Means SE_d</th>
<th>&quot;t&quot; Test of Significance t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 2-Test 3</td>
<td>200.1 17.9</td>
<td>196.5 9.5</td>
<td>-3.6</td>
<td>4.4</td>
<td>0.3</td>
</tr>
<tr>
<td>Test 2-Test 4</td>
<td>200.1 17.9</td>
<td>227.6 15.8</td>
<td>27.6</td>
<td>4.4</td>
<td>6.3</td>
</tr>
<tr>
<td>Test 2-Test 5</td>
<td>200.1 17.9</td>
<td>230.1 13.6</td>
<td>30.1</td>
<td>5.4</td>
<td>5.4</td>
</tr>
<tr>
<td>Test 3-Test 4</td>
<td>196.5 9.5</td>
<td>227.6 15.8</td>
<td>31.1</td>
<td>4.1</td>
<td>7.5</td>
</tr>
<tr>
<td>Test 4-Test 5</td>
<td>227.6 15.8</td>
<td>230.1 13.6</td>
<td>2.5</td>
<td>3.9</td>
<td>0.6</td>
</tr>
</tbody>
</table>

For 11 degrees of freedom a t of 2.20 is significant at the 5 percent level of confidence.
A Comparison of the Results Obtained for the "Steady" Group and the "Interval" Group

The differences of mean performance levels of both groups during the same training periods were shown in Table 3.

The results of the performance tests for both groups after two weeks of training exhibited a difference between the test means of 1.8 and a t ratio of 0.25. This difference was not statistically significant at the five percent level of confidence.

The mean performance scores for the two groups after four weeks of training indicated a difference between the means of 4.3 and a t ratio of 0.81. These results show no statistically significant difference between the scores at the five percent level of confidence.

For the six week period of training, the means of the final performances gave a difference of 1.1 and a t ratio of 0.28. This difference in score was not statistically significant at the five percent level of confidence.

The results obtained on the tests conducted at the end of two, four and six weeks indicated that there is no statistically significant difference at the five percent level of confidence between groups in the amount of improvement made in work output.
TABLE 3
A Comparison of the Significance of Mean Performance Scores Between the "Steady" and "Interval" Training Groups on Tests 2, Tests 3, Tests 4 and Tests 5

<table>
<thead>
<tr>
<th>Test</th>
<th>&quot;Steady&quot; Training Group</th>
<th>&quot;Interval&quot; Training Group</th>
<th>Difference Between the Means</th>
<th>Standard Error of the Difference Between the Means</th>
<th>&quot;t&quot; Test of Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M₁</td>
<td>SD₁</td>
<td>M₂</td>
<td>SD₂</td>
<td>M₂-M₁</td>
</tr>
<tr>
<td>Tests 2 AB</td>
<td>200.0</td>
<td>15.5</td>
<td>200.1</td>
<td>17.9</td>
<td>0.1</td>
</tr>
<tr>
<td>Tests 3 AB</td>
<td>198.3</td>
<td>23.1</td>
<td>196.5</td>
<td>9.5</td>
<td>-1.8</td>
</tr>
<tr>
<td>Tests 4 AB</td>
<td>223.3</td>
<td>19.7</td>
<td>227.6</td>
<td>15.8</td>
<td>4.3</td>
</tr>
<tr>
<td>Tests 5 AB</td>
<td>229.0</td>
<td>16.1</td>
<td>230.1</td>
<td>13.6</td>
<td>1.1</td>
</tr>
</tbody>
</table>

For 11 degrees of freedom t is significant at 2.20 at the 5 percent level of confidence.
CHAPTER VI

DISCUSSION

In the present study the work load for each training group ("steady" and "interval") was identical. However, the method of presenting the work (i.e., power) varied from group to group. This design was used to investigate the effectiveness of various training procedures upon work output.

The skiers tested by Sinisalo and Juurtola (1) as a group showed improvement in the timed ski-run, but no statistically significant difference was found between the times presented by the "constant speed" or the "interval" groups. Results of the present study would indicate that after a six week training period of pedalling a bicycle, set at a fixed resistance, to a predetermined work schedule, there is a statistically significant difference in favour of an increased work output as a result of the training. In this study the increase amounted to a fifteen percent improvement in performance on the test item presented. This was true for both training groups.

As the difference between the mean performance scores of each group after six weeks of training was not statistically significant it seems evident that no one of the methods is superior to the other. It would appear from the results of this study that if the amount of work applied in each method of training is kept equal, then the tested performance put forward by each group does not vary. However, it should be kept in mind that only a small number of subjects were used in this experiment and difficulty thus arises in forming generalizations as to the bearing of these results upon a large population sample. Also, six weeks of training may have been too short to allow any differences resulting from the methods
used to be apparent.

Neither group showed a statistically significant improvement as a result of the first two weeks of training. This would seem to indicate the possibility of a stabilizing period of conditioning and practice as indicated by Henry (2) or that the training load was too light to evoke a change in performance after only two weeks of training.

The greater amount of improvement in performance occurred after four weeks of training. A difference of 23.3 revolutions was recorded for the "steady" training group and 27.6 revolutions for the "interval" training group. No statistically significant difference was obtained at the five percent level of confidence between the mean test scores obtained by either group at the completion of four weeks of training. However, each group showed a statistically significant difference at the five percent level of confidence at the end of four weeks. In comparison, the differences between the means for the "steady" group and the "interval" group after six weeks of training were 29 and 30.1 revolutions, respectively. No statistically significant difference was obtained at the five percent level of confidence between the final scores of the groups.

The results indicate that a performance plateau was reached by the end of the fourth week of training. An increase in the work load required for the training sessions in the final two weeks did not alter the performance output at the completion of six weeks of training. It is evident that in this particular case an increase in the daily work dose did not necessitate an increase in the work output as revealed by the test at the completion of training for six weeks. Here it seems that no advantage was gained by application of the "overload principle" of training. However, the benefits of this increase in daily training dose for the last two weeks may have been
In a report of a study published after the completion of the present study, Mellerowicz et al (3) indicated somewhat similar results to those found in the present study. They divided twenty-four male students, aged eleven to nineteen years, into two groups, approximately equal in average weight, height and performance on a hand and arm ergometer test. The first group exercised on a non-intermittent program, while the second group trained according to an intermittent exercise program. The second group was sub-divided into two subgroups, which differed in the division of work and rest time. The total amount of work however, was equal for each group. After four weeks of training, three times a week, there was an average of twenty-three percent increase in performance, but no difference was found between the performances produced by the two methods of training. From the results of Mellerowicz's study and the present study it was seen that, perhaps it is not the type of training that affects work output but the amount of work accomplished in a training session.

The nature of the design of the present study was to allow some initial exploration into the effects of two training procedures upon work output. From the results obtained it is obvious that further investigation into training procedure is required. Investigation is needed to reveal the reasons for the lack of improvement in performance at the end of two weeks of training, i.e. to determine if this period was truly a stabilizing period or whether the training dose was below a threshold necessary to produce an increase in performance. The lack of improvement in work output as a result of the final two weeks of training, when the training dose was increased, also is in need of further investigation. This would necessitate investigation of training at the medium work dose compared to training at the heavier
work load. The medium training dose may be just as effective at producing an improvement in the work output as the heavier work load. Studies are required to determine the best training dose for producing increases in work output and the effectiveness of the application of the overload principle. An extension of the training period to cover a longer period than six weeks would give more insight into the effects of various work loads and training procedures upon work output. The six week training period may be too short a period to reflect the superiority of one particular type of training over another. It is suggested that further study of training methods should be carried out over a longer period than six weeks. Future investigation could include studies where subjects trained at an unaltered training dose for the duration of the experiment and studies where the overload principle was applied when an improvement in work output became evident from the results of testing at regular intervals.

The nature of the program adhered to by each group in this present study limits the interpretation of the results. However, within the limits of this study it would appear that so long as the work load in training is kept constant for both groups any difference between the means of the performance tests of the "steady" and "interval" groups at the end of two, four and six weeks of training could have occurred only by chance. Both methods of training were effective in producing improvement, over the initial performance scores, after four and six weeks of training. No performance increase occurred as a result of the last two weeks of training in either the "steady" or the "interval" group.

If a generalization could be drawn from this study pertaining to interval and steady paced training methods used in conditioning for middle distance
type track events, it would be that, provided work loads remain the same for both methods, no one method would be superior. Further investigation is required to determine the importance of the amount of work done during training compared to the increase in tested work output.


CHAPTER VII

SUMMARY AND CONCLUSIONS

Thirty-four male University of British Columbia first year students between the ages of nineteen and twenty-one, were selected from the required physical education activity program. Each student was tested on a fixed resistance type bicycle ergometer. The number of revolutions achieved in two minutes was recorded. Two groups were then formed by the "paired comparison" method and trained for six weeks. Both groups did the same amount of work in each training session but each group varied its method of work application, i.e. one group trained at a steady effort while the other group trained at a higher power but with regulated rest periods between bursts of power. Each group was subjected to a two minute test at the intervals of two, four and six weeks, after the commencement of training.

On the basis of statistical treatment, the following results were evident:

1. There was no statistically significant improvement of work output scores for either group after two weeks of training.

2. After four weeks of training, both groups exhibited marked improvement in work output scores which were statistically significant at the five percent level of confidence.

3. Tests after six weeks of training indicated statistically significant improvements in performance scores in both groups. These scores were statistically significant at the five percent level of confidence.

4. Both types of training, when compared, showed little difference in the results obtained at the end of two, four and six weeks of training.
There was no statistically significant difference between the means of each group at the end of two, four and six weeks of regulated training.

On the basis of these results, it seems evident that within the limitations of the study, there is no difference in work output obtained from the results of either "steady" or "interval" types of training provided the total work done by the members of either group is the same. (In both groups, however, a statistically significant gain in work output was evident after four and six weeks of training).
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APPENDIX
APPENDIX A

STATISTICAL ANALYSIS

Two groups were required, one for each method of training.

Steady training group: Group A \( N = 12 \)

Interval training group: Group B \( N = 12 \)

One test was administered upon a bicycle ergometer. This test was administered five times to each subject.

Procedure

1. Test 1 was administered to a group of subjects.
2. The subjects were ranked and placed into two groups, i.e. they were equated upon the performance in test 1.
3. Test 2 was administered to Group A and Group B one week after test 1.
4. The reliability co-efficient between test 1 and test 2 was then calculated.
5. Test 3 was administered.
6. Test 4 was administered.
7. Test 5 was administered.

General Statistical Outline

The following calculations were made:

1. The correlation of reliability co-efficient between test 1 and test 2 for groups A and B.
3. The significance of difference in performance of Group A on tests 2, 3, 4, 5.
4. The significance of difference in performance of Group B on tests 2, 3, 4, 5.

Procedure and Formulae

1. The correlation of the reliability co-efficient between test 1 and test 2, for group A and group B combined, was calculated.

Tabulation of the Data

The correlation between test 1 and test 2 was calculated by means of the Pearson Product-Moment Formulae

\[ r_{12} = \frac{\Sigma x_1 y_2}{N \sigma_1 \sigma_2} \]

where \( N \) = the total number of subjects
\( \sigma_1 \) = standard deviation of the mean of test 1
\( \sigma_2 \) = standard deviation of the mean of test 2
\( \Sigma x_1 y_2 \) = sum of the products of the deviations from the two means
\( r_{12} \) = co-efficient of correlation

2. The significance of the difference in mean performance of group A between tests 2 and 3, test 3 and 4, tests 4 and 5, tests 2 and 4, tests 2 and 5 was calculated by the method of obtaining the difference between two correlated means outlined in Garrett (1, p. 227). This difference was accepted at the five percent level of confidence.
INDIVIDUAL SCORE CARDS

Name ........................................................................................................
Age ................................................................. Phone No .......................  
Weight ................................................................. Training Group: Interval 
Height ................................................................. Steady 
Test 1 .................................................................
Test 2 .................................................................
Test 3 .................................................................
Test 4 .................................................................
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SPECIFICATIONS OF THE BICYCLE ERGOMETER

The bicycle ergometer used in this study was a frictional type ergometer manufactured by J.A. Preston Corporation, 175 5th Ave., New York, N.Y. It was chain driven, with a solid iron fly wheel, thirteen inches in diameter and one and a half inches deep. Force was applied to the flywheel by adjusting a calibrated "Hekure" spring balance, which was attached to a friction band of chrome leather. Tension upon the leather band increased the force applied to the flywheel.

Unfortunately, with this type of ergometer no accurately determined work load can be made.

A mechanical revolution counter was fixed upon the frame to record each revolution of the drive wheel. These revolutions were used as an index of the work done by the subjects. The force applied to the flywheel remained constant during the experiment.