THE EFFECTS OF PHYSICAL EXERTION ON IMMEDIATE CLASSROOM MENTAL PERFORMANCE OF SECOND-GRADE ELEMENTARY SCHOOL CHILDREN

DISSERTATION

Presented to the Graduate Council of the North Texas State University in Partial Fulfillment of the Requirements

For the Degree of

DOCTOR OF EDUCATION

By

Carl P. Gabbard, B. S., M. Ed.

Denton, Texas

December, 1977

The aim of this investigation was to analyze the effects of induced physical exertion on the performance of an immediate mathematical mental ability task among second-grade students. The purpose of the study was to gain information concerning the effects of physical exertion on a mathematical mental task and to evaluate each of four experimental treatment periods (twenty, thirty, forty, and fifty minutes) used to induce physical exertion. Another purpose was to determine whether males or females were more affected by experimentally induced treatments of physical exertion.

The study involved 106 second-grade students selected from a single elementary school during the spring of 1977. During the students' regularly scheduled physical education class periods they were administered four experimental treatments of induced physical exertion. The treatments lasted for durations of twenty, thirty, forty, and fifty minutes. The movement activities performed during the physical exertion sessions were specific relay game
activities that were performed in a continuous cycle as the duration of the sessions got longer.

The students were assigned six mathematical mental ability tasks. Four of the tasks were performed five minutes after the completion of each of the four physical exertion sessions. The first mental task (pre-test) and sixth mental task sessions were performed without induced physical exertion and the comparison between them served as the study control. Each mental ability task was composed of thirty-six first-grade level problems that required adding and subtracting with no borrowing or carrying functions. The students were given two minutes to complete each of the six mental tasks. The mathematical task scores served as the dependent variables and were statistically analyzed.

A one-way analysis of variance for repeated measures was used to test for significant differences among the six experimental treatments. The Dunnett multiple comparison test was utilized to determine which treatment means differed significantly when a significant F-ratio was found. The .05 level of significance was the level at which the six hypotheses were either accepted or rejected. The one-way analysis of variance with the mean difference option was utilized to compare male and female mean difference performance.

When the one-way analysis of variance revealed significant differences, the Dunnett test revealed that the only significant difference when comparing the pre-test to the
five post-tests was the fifty minute treatment. The fifty minute treatment indicated significantly higher scores when compared to the pre-test (control) and the four other post-tests. The one-way analysis of variance with mean difference option revealed no significant differences between male and female mean difference performance.

It was concluded that fifty minutes of prolonged physical exertion as induced by relay game activities had a positive effect on certain mathematical tasks. This conclusion was based on the comparison of the fifty minute treatment performance to the pre-test treatment performed without induced physical exertion. Another conclusion derived from the data was that physical exertion periods of twenty, thirty, and forty minutes had no significant positive or negative effect on certain mental performance when compared to a non-induced physical exertion treatment. It was also concluded that there were no significant differences between male and female mean difference performances.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>LIST OF TABLES</th>
<th>v</th>
</tr>
</thead>
</table>

**Chapter**

1. **INTRODUCTION**
   - Statement of the Problem
   - Purposes of the Study
   - Hypotheses
   - Background and Significance
   - Definition of Terms
   - Limitations
   - Basic Assumptions

2. **REVIEW OF RELATED LITERATURE**
   - The Effects of Fatigue and Physical Exertion on Mental Performance
   - The Effects of Fatigue on Motor Performance
   - Theories of Fatigue
   - Summary

3. **PROCEDURES OF THE STUDY**
   - Selection of the Sample
   - Research Design
   - Selection and Description of the Mental Ability Task
   - Collection of the Data
   - Analysis of the Data

4. **PRESENTATION AND ANALYSIS OF DATA**
   - Presentation of Data
   - Discussion of the Findings

5. **SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS**
   - Summary
   - Conclusions
   - Recommendations
LIST OF TABLES

Table                      Page

I. Design of Testing Procedures ............... 26
II. Examples of Mathematical Problems .......... 29
III. Testing Schedule .......................... 35
IV. Summary Table of One-Way Analysis of Variance .... 43
V. Summary of Group Means and Treatments ........ 43
VI. Summary of the Fisher’s t and Dunnett Test ... 45
VII. Summary of Dunnett Test Comparisons of Pre-test Means to Post-test Means ............ 47
VIII. Summary of Variable Explanation for Test of Mean Differences Between Scores .... 49
IX. Summary of Mean Differences for Male and Female Groups .................. 49
X. Summary of the One-Way Analysis of Variance Comparing Mean Differences ............... 51
CHAPTER I

INTRODUCTION

The theory of overexertion as a limiting factor in classroom performance has often been associated with the elementary school child (24, 25). Assertions as to what levels of fatigue are debilitating, or what levels of physical exertion enhance performance have been unfounded. Davey (9) reported that it is a common observation that many athletes in an apparent state of fatigue make wrong decisions at a critical stage, thus lowering the standard of their performance. Such evidence as stated above would make one wonder if an elementary school child could reach such a state of mental debilitation after the physical exertion usually experienced in elementary physical education. Past studies have determined that physical exertion can produce various levels of fatigue and debilitation (1, 3, 12, 22, 26). In addition, there is empirical evidence that shows that physical exertion at certain levels can enhance mental performance (9, 10, 18). However, research using the elementary child as a subject has not investigated the relationship between physical exertion, physical education class duration, and mental performance. Because the physical exertion is experienced by the child during physical education
class or free play or both, these bouts of physical exertion need scientific investigation.

The vast majority of physical education research completed in the area of fatigue has highlighted the effects of fatigue on certain motor performances and not on classroom mental performance (2, 7, 8). Research that has involved the effects of fatigue on mental performance has generally used adult subjects and not elementary-age children (9, 10, 16). A need exists for a coordinated research effort among physical educators and elementary curriculum specialists. This coordinated effort should produce significant findings concerning the relationship between physical exertion and mental performance.

The duration of a physical education class varies from school to school. Usually, the balance of the schedule determines the length of time spent in physical activity. However, it is not unusual for physical education classes to be created and adjusted in order to complete a full schedule. As a result, primary and intermediate physical education classes are often equal in length. Thirty to forty-five minutes of physical activity is commonly assigned to both primary and intermediate grades (19). These times may induce distinctly different levels of debilitating fatigue, or may enhance mental performance. Since either is possible, but the degree of possibility is undetermined in the literature, this variable needs to be examined in a research setting. Such
evidence as might be found by such a study could provide information needed by educators to better understand the physical capabilities of the elementary child.

The Texas Education Agency recommends that kindergarten through third grades have thirty minutes of physical activity daily (27). In consideration of this recommendation the questions become slightly more specific. Why did the agency select that particular duration as a primary grade recommendation? Why was this recommendation similar for both kindergarten and third grades, when each group brings such different needs to the education setting?

This study has been designed to aid in the effectuality of the education process by examining the following specific questions: To what degree will different durations of physical exertion affect the student's performance on a mental ability task? At what length of time will physical education activities affect performance on mental ability tasks? Are male and females affected differently by physical exertion? What is the relationship of physical exertion to immediate classroom performance?

Statement of the Problem

The problem of this study was to determine the effects of physical exertion on a mental ability task administered to second-grade students.
Purposes of the Study

The purposes of this study were to determine

1. The effects of physical exertion on a mathematical mental ability task among second graders, and to evaluate each of four activity periods (duration: twenty, thirty, forty, fifty minutes) used to induce physical exertion;

2. If students are performing under possible debilitating conditions by being asked to complete immediate classroom tasks after certain periods of physical exertion;

3. If students are stimulated by certain levels of physical exertion and improve mental performance scores on certain mathematical mental tasks; and

4. Whether males or females are more affected by physical exertion as it relates to immediate classroom performance on a mathematical task.

Hypotheses

The research problem undertaken in this study required the advancement of six major hypotheses. All hypotheses were tested at the .05 level of significance.

1. There will be no significant differences between the pre-test scores and the twenty minutes post-test scores.

2. There will be no significant differences between the pre-test scores and the thirty minute post-test scores.

3. There will be no significant differences between the pre-test scores and the forty minute post-test scores.
4. There will be no significant differences between the pre-test scores and the fifty minute post-test scores.

5. There will be no significant differences between the pre-test scores and the final post-test scores when taken under non-physical exertion conditions.

6. There will be no significant differences between the males and females on the pre-test scores and the deviation from these scores by the post-test scores.

Background and Significance

The information concerning the relationship between physical exertion and fatigue has been indeterminate in defining specific degrees of performance limitations (17). There is probably no single word in our vocabulary which has been less adequately defined, yet few individuals would deny personal acquaintance with it. Definitions of fatigue are almost as numerous as the articles that have been written about it. The fact that fatigue cannot be specifically defined led McFarland (17) to conclude that fatigue was one of man's most perplexing problems.

Fatigue and its effects on performance have been investigated through research since World War I (5). The focus of research since that beginning has involved the following areas: (a) industrial fatigue, (b) aviation fatigue, (c) automobile driving, and (d) motor performance (5). The research concerning mental performance, especially childhood performance and fatigue, has been quite limited.
Fatigue has generally been divided into two categories: mental and muscular. Grandjean (14) described fatigue as being either acute or chronic. Acute fatigue was defined as usually being associated with muscular work. It results in a temporary loss of efficiency, which is relieved by rest. Grandjean described chronic fatigue as a state which may not be relieved by rest or sleep, and results from an accumulation of physiological factors.

There have been many different explanations of how fatigue occurs. Grandjean described both physiological and psychological factors involved in the fatiguing process. He reported three physiological factors: oxidation of the nerve tissue, an accumulation of lactic acid in the blood, and an exhaustion of energy reserves.

While researching the problem of why people in an apparent state of fatigue make wrong decisions, Davy (9) reported what he considered a popular, but unfounded theory of fatigue. He stated that some researchers believe fatigue to be a state of hypoxia, affecting the brain during and after severe physical exertion. He further stated that this was similar to the oxygen theory that described fatigue as an oxygen deficit, perhaps in the muscle, that may interfere with decision making.

Adams (1) based much of his work in the field of motor performance and fatigue on a stimulus-response theory. He concluded that the strength of the memory trace was weakened
under fatigued conditions. Cameron (5) concluded that fatigue effects are closely related to the effects of sleep deprivation. He also stated that time was the only unique variable associated with fatigue.

In 1947, Bartley and Chute (3) investigated the explanatory concepts of fatigue. They concluded that fatigue should only be defined in subjective feelings of lassitude and disinclination toward activity. They suggested the use of the word impairment to identify the true reduction of physical capacity associated with fatigue. They concluded that the reduction of physical performance resulted from an accumulated oxygen debt in muscle tissues.

There have been a number of studies conducted in the area of mental performance, physical exertion, and fatigue. Ellingstad and Heimstra (11) concluded that prolonged physical exertion performed during a fifteen-hour session was not a significant factor in decreasing mental multiplication performance. In another study, McFarland (17) concluded that performance of a simple but prolonged repetition of mathematical tests would show a loss of efficiency due to fatigue. Facaoaru (12) found that industrial workers performed problem-solving tests less efficiently after six hours of their ten-hour work shift.

Davey (9), in one of the more specific studies concerning physical exertion and performance, concluded that submaximal amounts of physical exertion improved mental
performances on certain mental attention tests. Marteniuk (18) and Duffy (10) also completed studies supporting Davey's findings.

The area of motor performance and fatigue has been researched extensively by physical educators, physiologists, and psychologists. Bartz and Smith (4) investigated the effects of moderate standardized work load upon the learning of a gross motor skill. They concluded that no significant differences existed between those that worked and controls who did not exert themselves before learning to balance on a stabilometer. Komoike and Horiguchi (16), while conducting a study involving key punch operators and typists, found a significant decrease in punching pressure and punching speed when comparing early work with later punching. They also concluded that the decrease was due to a kind of fatigue following the punching work.

Jones and Hanson (15) analyzed individual gross body movements before and after fatigue-inducing exercise. They concluded that individual differences in style of performance persisted despite the effects of fatigue. Cochran (8) and Phillips (21) agreed that fatigue had a favorable influence on both performance and learning of certain novel motor skills. Schmidt (23) and Godwin (13) concluded that fatigue was a performance rather than a learning variable, but found no significant decrement in performance of a gross motor task under fatigued conditions.
Caplan (6) conducted a study to test the hypothesis that fatigue and impaired performance could transfer from one set of muscles (legs) to another set of muscles (arms). It was found that arm work output was impaired 14 per cent when preceded by heavy leg exercise. Pearson (20) found a psychological variable involved with fatigue performance. He concluded that the way one feels and performance are not necessarily related. Wrisberg and Herbert (28) conducted a study to investigate the effects of local and general fatigue on the performance of a timing task involving well-practiced subjects. They concluded that fatigue may alter the timing mechanism of well-practiced subjects.

The significance of this study is based on the following stated needs: (a) research in the area of elementary school children, (b) information concerning the elementary school child and his physical capabilities, and (c) research in the area of elementary physical education and physical exertion as it relates to classroom mental performance.

**Definition of Terms**

Terms used in this study are defined as follows.

**Mental ability task.**—A measurement of timed mathematical computation performance is referred to as a mental ability task.
**Physical exertion.**—The result of performing movement activities which occur in a physical education class period is referred to as physical exertion.

**Fatigue.**—That which may cause a decrease in function or efficiency as a result of physical exertion induced during physical education class is referred to as fatigue in this study.

**Limitations**

1. This study was limited to a population composed of second-grade males and females.

2. Measurement of physical exertion evaluated in this study was related to relay game activities performed in a continuing cycle.

**Basic Assumptions**

1. It was assumed that any extra mathematical practice involving adding and subtracting, would not be a significant factor in the performance of the mental ability task used in this study.

2. It was assumed that no significant increase in either mental or physical learning would take place during the span of the six experimental treatments included in this study.
3. It was assumed that the subjects exerted themselves equally throughout the four experimental physical exertion sessions.
CHAPTER BIBLIOGRAPHY


CHAPTER II

REVIEW OF RELATED LITERATURE

The Effects of Fatigue and Physical Exertion on Mental Performance

Gutin and DiGennaro (16) conducted a study to investigate the performance of subjects working long addition problems in mathematics after an exhausting treadmill run. It was found that the exertion had a significant negative effect on mathematical accuracy, but no significant effect on speed of performance. Ellingstad and Heimstra (11) studied performance changes during a sustained operation of a complex psychomotor tracing task. Also tested during the fifteen-hour session was mental multiplication. There was no clearly established decrement on the multiplication task; therefore, the investigators concluded that the complex psychomotor task performed during the prolonged session was not a significant factor in mental multiplication performance.

Dimitrova (9) studied the features of voluntary effort connected with surmounting the feelings of fatigue. Adult subjects performed both mental and motor work during the experimental session. Subjects were given varied goals to strive toward during the session. It was concluded by Dimitrova that difficulties induced by fatigue could be overcome. It was also concluded that fatigue difficulties vary widely among
individuals. Dimitrova hypothesized that factors such as image and self-evaluation play an important role in sur-
mounting the difficulties induced by fatigue.

Facaoaru (13) investigated the influence of fatigue on problem-solving abilities among engineers, supervisors, and industrial machine operators. Subjects were tested during their ten-hour work shifts. At various intervals during the work shift, testing was conducted using problem-solving techniques as the basic test item. The subjects' test performances were significantly lower after six hours of work. McFarland (12) studied the performance of subjects during simple, but prolonged repetition of mathematical and color-naming tests. He concluded that the subjects progressively lost efficiency during the prolonged sessions.

One of the most recognized studies concerning physical exertion and mental performance was conducted by Davey (8) in 1973. Subjects pedalled a bicycle ergometer for varying periods of time and were tested for mental performance. After different amounts of physical exertion the subjects were administered the Brown and Paulton Test of Attention. Davey concluded that a sub-maximal amount of physical exertion improved mental performances on the Brown and Paulton test. He also reported that the evidence suggested physical exertion affects mental performance by raising the level of arousal. Davey described the process as the inverted-u-relationship theory. He also concluded that too much arousal
could produce lower mental performance results. Davey reported that in 1972 he conducted a similar study and found comparable results.

The Effects of Fatigue on Motor Performance

The following review reports on literature in the areas of motor learning and performance. The majority of the literature involving fatigue is found in these areas. The area of motor learning and the processes involved in that learning are quite similar to mental learning processes (17, p. 8). A review of motor learning and performance under conditions of physical exertion is necessary for a thorough understanding of the term fatigue.

Godwin and Schmidt (14), in a study of the effects of fatigue on learning a motor skill, concluded that fatigue was a powerful learning variable. In this study a learning variable was defined as one causing a more lasting change in behavior. They concluded that the learning of a motor skill may be much more affected by fatigue than the performance of an already learned motor skill. Schmidt (21) disagreed with Godwin and Schmidt, stating that fatigue was a performance variable rather than a learning variable. Schmidt defined a performance variable as one which temporarily affects the level of proficiency during motor learning. Schmidt also concluded that fatigue had no significant effect on learned motor skills.
Cochran (7), after studying the effects of fatigue on learning to perform a novel motor task concluded that the fatigued state of the learner had a variable influence on both performance and learning of certain novel motor skills. Carron (6) instituted a study to ascertain if the stage in practice at which fatigue was introduced could be a critical factor influencing motor performance and learning. He imposed a fatiguing task at both early and late intervals in the practice session and found that performance rather than learning was impaired after the fatiguing task. Accordingly, Alderman (2) and Phillips (20) utilized similar techniques to determine if fatigue impaired motor learning. Both concluded that fatigue did not influence motor learning. These findings were disputed in the Godwin and Schmidt study where it was reported that Alderman and Phillips probably allowed too much recovery time after induced fatigue which allowed their subjects to perform as well as non-fatigued subjects.

Benson (4) studied the effects of practice performed during a fatigued state on the learning of jumping and juggling skills. Benson concluded that learning to use speed as a component in the jumping task was impaired in the fatigued state. However, learning in terms of the accuracy of jumping was enhanced in a fatigued state. He also concluded in another part of his study that learning to juggle was enhanced in a fatigued state. Benson's overall conclusion
was that fatigue has a differential effect on learning, dependent upon the nature of the task being learned.

Pearson (19) conducted a study in which adult subjects trained on a complex perceptual motor task for fifty minutes, rested ten minutes, and then continued training for a period of three hours. Pearson used a twelve-item checklist to measure feelings of fatigue. As a result, Pearson found that correlations between task proficiency criteria and checklist data were not significant. It was concluded that the way a subject says he feels prior to a three-hour motor task and the way he performs are not necessarily related. It was also indicated that the subject's feelings do not necessarily parallel performance.

Theories of Fatigue

The following review contains theories of fatigue and physical exertion as they are related to mental and physical performance.

Marteniuk (17) and Duffy (10) have drawn very similar conclusions concerning the effects of physical exertion on mental performance. Both researchers based their conclusions on the inverted-u-relationship theory. They hypothesized that for every type of behavior there exists an optimal degree of arousal, usually of moderate intensity, that produces maximum performance. Levels of arousal below or above this optimum amount are said to produce inferior
performances. The relevance of the activation theory, as Duffy referred to it, was the postulation that there was an optimal state of the central nervous system underlying maximum performance. Marteniuk reported that arousal can be increased through physical exertion, and that it not only facilitates motor performances, but also increases cognitive performance skills (17, p. 40). Marteniuk concluded that there was evidence to indicate that certain levels of physical exertion had a positive influence on both mental and motor performance. He also reported that the information processing ability was enhanced by certain levels of physical exertion.

Cameron (5) hypothesized that fatigue effects were closely related to the effects of sleep deprivation. He also reported that the importance of such long-term effects suggested that the time required for recovery may be a useful method of quantifying severity of fatigue. Cameron also stated that the only variable uniquely identifiable with fatigue was time. He concluded that fatigue may simply be the result of sleep deprivation.

Adams (1) based much of his work in the field of motor performance and fatigue on a stimulus-response theory. He concluded that the strength of the memory trace was weakened under fatigued conditions and resulted in a reduced number of correct responses in a series of trials. Simonson (22), in his book on fatigue physiology, wrote that
the intensity of the exercise was the main factor in determining the effect of fatigue on performance of a certain task. In reference to motor performance, he stated that evidence exists which proves that recovery in the form of active pauses or slow movement may be more beneficial to physiological recovery than complete rest.

In 1947 Bartley and Chute (3) investigated the possible explanations of physiological fatigue. They concluded that fatigue was related to an accumulated oxygen debit in the muscle tissues. It was also suggested that fatigue should be defined in less specific terms since there were so many undefined factors involved. Bartley and Chute concluded that fatigue could in certain instances impair and reduce the physical capacity of an individual.

Summary

The review of the literature made it quite clear how diversified the effects of fatigue and physical exertion are on mental and motor performance. Even the evidence most closely related to this study presented differences in findings. Gutin and DiGennaro (16) and McFarland (12) concluded that physical exertion had a negative effect on the performance of mathematical skills. Ellingstad and Heimstra (11) found that mental multiplication was not affected by physical exertion over a fifteen-hour testing period. Facaoaru (13) found that the problem-solving abilities of various industrial
workers was decreased after six hours of their ten-hour work shifts. All of the above studies had the primary purpose of investigating the effects of fatigue on mental performance, although fatigue was induced by physical exertion.

Davey (8) investigated specifically the effects of physical exertion on mental performance. He concluded that a sub-maximal amount of physical exertion improved mental performance on an attention test. Duffy (10) and Marteniuk (17) reported evidence that supported Davey's findings. All three researchers based their conclusions on the inverted-u-relationship theory. Marteniuk stated that arousal, as defined by the inverted-u-relationship, can be increased through exertion, and that it not only facilitates motor performances, but also increases cognitive performance skills. Further research is necessary to provide information relating to the effects of physical exertion on the mental performance of elementary-age children.
CHAPTER BIBLIOGRAPHY


CHAPTER III

PROCEDURES OF THE STUDY

Selection of the Sample

The subjects utilized for this experiment were 106 second-grade students selected from a single north central Texas elementary school during the spring of 1977. The sample consisted of four second-grade classes, representing the entire population of second graders. The population of each class ranged from twenty-five to twenty-eight students. The total sample consisted of sixty-three males and forty-three females. Ninety-six per cent of the subjects were in the seven- and eight-year old category.

While 106 subjects participated in the study, only ninety-five subjects' scores were analyzed: fifty-nine males and thirty-six females. Eleven subjects were disqualified because of absences during the experimental sessions. A subject had to participate in all six experimental treatments in order to be considered part of the analysis of data. During the two-week period of data collection, four new students enrolled in the second-grade classes. These four students participated in the experiment, but their scores on the ability tasks were not included at the end of the experimental treatments because they did not meet the participation.
criterion. Instructions for the experimentally induced physical exertion activities were given to the new students by the teacher's aide to insure that the procedures of the study were not disrupted.

Research Design

The design of this study was repeated measures with equivalent materials. The independent variables were the six experimental treatments of physical exertion; four duration periods of twenty, thirty, forty, and fifty minutes, and two control treatments involving no physical exertion. A pre-test and final post-test acted as controls, with the subjects participating in the mental task only. The dependent variable was the mathematical mental ability task which was undertaken after each physical exertion treatment. Four intact class groups made up the sample. Each subject experienced the same order of all six treatments. The design was implemented as outlined in Table I.

**TABLE I**

**DESIGN OF TESTING PROCEDURES**

<table>
<thead>
<tr>
<th>Duration of Physical Exertion</th>
<th>Five-Minute Interval</th>
<th>Two-Minute Mental Ability Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pre-test (no exertion)</td>
<td>x</td>
<td>Form A</td>
</tr>
<tr>
<td>2. Twenty Minutes</td>
<td>x</td>
<td>Form B</td>
</tr>
<tr>
<td>3. Thirty Minutes</td>
<td>x</td>
<td>Form C</td>
</tr>
<tr>
<td>4. Forty Minutes</td>
<td>x</td>
<td>Form D</td>
</tr>
<tr>
<td>5. Fifty Minutes</td>
<td>x</td>
<td>Form E</td>
</tr>
<tr>
<td>6. Post-test (no exertion)</td>
<td>x</td>
<td>Form F</td>
</tr>
</tbody>
</table>
Two class groups were combined to create two large treatment groups for participation in the physical exertion sessions. Thus, a total of two class groups or fifty-four children were included in each treatment at one time. The design reflected the actual physical education schedule utilized during the normal school week. The testing schedule was organized to fit the actual school week routine. The four test groups were examined separately in their own classrooms for the mental ability tasks. Each group participated in six experimental sessions, the first and last of these consisting only of the mental ability task (without induced physical exertion). The four experimental physical exertion sessions, which took place during the groups' regular physical education period, spanned the following durations: (a) twenty minutes, (b) thirty minutes, (c) forty minutes, and (d) fifty minutes.

Selection and Description of the Mental Ability Task

Instrument Development

A review of literature revealed that no single mental ability task could be judged adequate for use in this study. Therefore, a mental task had to be developed. The mental ability task used for this study had the following qualities: (a) it was flexible in that it was altered without losing test validity (the tests required random number changes six
times to accommodate the six mental ability tasks), (b) the level of difficulty did not change throughout the six testings, and (c) the subjects were already familiar with the types of mathematical problems presented in the mental task.

The purpose of the mental ability task was not to evaluate mathematical achievement, but to measure mathematical performance under certain pre-determined experimental conditions. The initial testing was conducted under non-physical exertion conditions (pre-test). Significance was based on deviation from that test score.

The mental ability task selected for this study was a mathematical computation test. Each student was asked to complete as many problems as possible in two minutes. The total number of problems on each test was thirty-six, which was beyond the working capability of the second-grade student (this factor was established during the pilot study).

The level of difficulty remained the same in all six applications of the test. In order to establish a level of difficulty that all students could achieve, but still provide a challenge, the level of proficiency required was equal to that recommended for accomplished first graders. The pilot study determined that all students could work at least three problems correctly in the allotted time. The types of mathematical problems used in the study were selected from the school district first-grade mathematics text. The same
text had been employed instructionally at the first-grade level for the past three years (1). 

To insure a comparable level of difficulty throughout the six tests, the following methods were used: (a) problems were selected equally from the following three computational procedures listed in Table II; (b) six lines with six problems on each line completed the test (each of the six lines contained two of each type of problem as shown in Table II); (c) problems on each line were changed using the following procedures: (1) number combinations were changed in each problem, (2) the order of the types of problems was changed in each line. (See Appendix A for test instruments.)

**TABLE II**

**EXAMPLES OF MATHEMATICAL PROBLEMS**

<table>
<thead>
<tr>
<th>Addition of Three Single Digit Numbers</th>
<th>Addition of Two Digit Numbers Without Carrying</th>
<th>Subtraction of Double Digit Numbers Without Borrowing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>43</td>
<td>54</td>
</tr>
<tr>
<td>3</td>
<td>+33</td>
<td>-42</td>
</tr>
<tr>
<td>+3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It should be noted that first-grade students taught from this textbook (1) were not required to learn the carrying and borrowing functions in addition and subtraction. This is the unique difference between first-grade and second-grade proficiency; hence, no problems requiring these functions were selected.
Since the students were participating in regular mathematical skill activities as a part of regular classroom activity during the study, an explanation of that activity follows.

The time devoted to mathematical studies took place directly after the administration of the mental ability tasks. The remaining time, approximately thirty-five minutes, was organized by the classroom teacher to include regularly taught computational skills and mathematical problems. Upon questioning the regular classroom teacher prior to initiating the treatment phase of this study, it was determined that mathematical instruction dealt with the functions of carrying and borrowing large sets of numbers. The method used by the subjects to solve problems on the mental ability task consisted of adding and subtracting numbers which did not require the more complex functions of borrowing and carrying.

It was assumed that the extra mathematical practice which took place during the two week experimental period did not aid significantly in the ability of the subjects to perform the mental ability tasks for the following reasons: (a) a pilot study established that adding and subtracting numbers which did not require borrowing and carrying was an already acquired skill, (b) a pilot study which tested twelve students on three of the mental ability tasks, but without induced physical exertion determined that over a five-day period (tested on Monday, Wednesday, and Friday) no
significant differences between test scores existed, thus indicating no significant learning effects.

The subject's classroom teacher administered the tests in an attempt to create a regular classroom situation. The results of the tests were scored by using the following procedures: (a) each correct response was scored as two, and (b) each incorrect response received no points. The two-point method was used in scoring because of preference in scoring values.

**Pilot Study**

A pilot study was conducted during March of 1977. Its purposes were to assess instrument validity and reliability, and to determine future procedure. Specifically, the purposes of the pre-study were to determine the following: (a) the difficulty level of the mathematical ability task, (b) the amount of time required to perform the task, (c) the number of problems to be placed on each task, and (d) the reliability of the testing procedure.

Students for the pilot study were selected from a school other than the one where the actual study took place. Twelve second-grade students, six males and six females, were selected as subjects. Teachers from each of four selected classes were instructed to choose participants who scored at the high, medium, and low levels on mathematical achievement tests that were administered one month earlier as part of
the school's testing program. The pilot tests were administered by the students' classroom teacher.

To test for difficulty, the students were given two sample tests composed of ten problems each. One test consisted of second-grade problems utilizing borrowing and carrying functions. The second test consisted of first-grade problems which contained no borrowing and carrying functions. The students were given two minutes to complete the ten problems. The tests were separated by an interval of ten minutes. The results were as follows: (a) the first test using second-grade problems resulted in one student completing no problems correctly and two students completing but one problem correctly, and (b) the second test using first-grade problems resulted in all twelve students completing at least three problems correctly. As a result of the pilot study findings, the first-grade problems were selected for the mental ability task, based on a lower limit where all students were able to complete at least one problem correctly.

Since the two-minute time limit was used in the first part of the pilot study, and was judged by the participating teachers and district elementary supervisor to be more than adequate time for the completion of the test, it was accepted for study procedure. It was observed by the classroom teachers that on the first part of the pilot, the high and medium achievers completed the ten problems in approximately one-half of the allotted time.
To determine the number of problems to put on the mental ability task, the following method was used. Using a two-minute time limit and fifty problems, the teachers administered the test consisting of first-grade problems to the four high achievers. High achievers were used based on the premise that they would accomplish the largest number of problems. The largest number completed was thirty problems. The following day, the number combinations in each problem were altered and teachers were asked to repeat the test. The largest number correctly completed on this re-administration was thirty-two. As a result of this pilot procedure, it was concluded that thirty-six problems on each mental ability task would provide more problems than subjects could reasonably be expected to complete.

To determine reliability, the same twelve students who participated in the first reported pilot were used. They were administered the pre-test A along with test B and test C without prior induced physical exertion. The tests were administered in order of A, B, and C on Monday, Wednesday, and Friday. They were administered by the subjects' classroom teacher. The tests were taken at the same time daily: after lunch and prior to physical education class. The tabulations were performed and tested for reliability using the Pearson Product Moment Correlation. Employing this technique, scores from the pre-test A were correlated with the test B scores; the result of this correlation was $r = .88$. 
The second correlation consisted of the pre-test A and test C scores; this second correlation was \( r = .90 \).

**Collection of the Data**

The experimental portion of the study lasted two weeks (ten school days). Each session of physical exertion started at the same time daily, 1:40 p.m. (see Table III). This coincided with the regularly scheduled physical education class. The mental ability task session began five minutes after the termination of the physical exertion session. The four test groups were coded as a, b, c, and d, thus representing the four second-grade classrooms.

To meet the demands of this study, the duration of time spent in physical education classes was extended. The regularly assigned physical education class session lasted thirty minutes. This meant that only the last two experimental sessions exceeded the assigned time.

The students in all classes were not told that a study was being conducted or that some sessions were extended in duration. Although no subject questioned the increase in duration, in the event that this might have happened, the teachers were prepared and asked to reply, "Aren't you lucky!"

During the two week experimental period the students had a recess from 10:00 to 10:20 a.m. Class scheduling did not allow further physical activity until the afternoon experimental treatments. The following table represents the actual treatment schedule used in this study.
### TABLE III
**TESTING SCHEDULE**

<table>
<thead>
<tr>
<th>Session</th>
<th>Treatment</th>
<th>Group</th>
<th>Physical Exertion Start and Finish</th>
<th>Mental Test Start</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pre-test</td>
<td>abcd</td>
<td>x</td>
<td>1:40</td>
</tr>
<tr>
<td>2</td>
<td>20 min.</td>
<td>(ab)</td>
<td>1:40-2:00</td>
<td>2:05</td>
</tr>
<tr>
<td>3</td>
<td>20 min.</td>
<td>(cd)</td>
<td>1:40-2:00</td>
<td>2:05</td>
</tr>
<tr>
<td>4</td>
<td>30 min.</td>
<td>(ab)</td>
<td>1:40-2:10</td>
<td>2:15</td>
</tr>
<tr>
<td>5</td>
<td>30 min.</td>
<td>(cd)</td>
<td>1:40-2:10</td>
<td>2:15</td>
</tr>
<tr>
<td>6</td>
<td>40 min.</td>
<td>(ab)</td>
<td>1:40-2:20</td>
<td>2:25</td>
</tr>
<tr>
<td>7</td>
<td>40 min.</td>
<td>(cd)</td>
<td>1:40-2:20</td>
<td>2:25</td>
</tr>
<tr>
<td>8</td>
<td>50 min.</td>
<td>(ab)</td>
<td>1:40-2:30</td>
<td>2:35</td>
</tr>
<tr>
<td>9</td>
<td>50 min.</td>
<td>(cd)</td>
<td>1:40-2:30</td>
<td>2:35</td>
</tr>
<tr>
<td>10</td>
<td>Post-test</td>
<td>abcd</td>
<td>x</td>
<td>1:40</td>
</tr>
</tbody>
</table>

Class groups were combined (ab and cd) and became treatment groups who participated in separate physical exertion treatment sessions. This combination plus treatment on every other day represented experimental design as well as the actual weekly routine for physical education class.

Each subject was given a pre-test consisting of one trial on the mental ability task. This pre-assessment served as a control in which the subjects performed the mental ability task without induced physical exertion. A
post-assessment of the mental ability task without induced physical exertion was also administered on the final day to provide data establishing the subject as his own control. The post-assessment was also administered to determine if learning could have intervened and caused one of the sets of control scores to be significantly different from the other.

The tests were scored and recorded on the subjects' test group score and information sheets (see Appendix B).

For the administration of the physical exertion sessions, time began when all the subjects had entered the gymnasium and assumed an assigned spot. The day before the experimental treatments began the subjects were given the opportunity to practice the physical exertion activities. At this time the subjects were asked to select a position in a relay line. They were told to keep the same position in the same line for the next two weeks. They were also told that their relay performance would be observed for the next two weeks. It was explained to them that the purpose of this two-week relay session was to assess overall group fitness. The gymnasium used for the study was air-conditioned and maintained at a constant temperature of seventy-two degrees Fahrenheit during treatment.

After the predetermined duration of exertion, the subjects were given five minutes to return to their classrooms. They were to take their seats and prepare for the selected
mental ability task. After the five minutes had expired, as timed on a stop watch, the classroom teacher began standardized instructions for the mental ability task (see Appendix C).

Each teacher participated in a training session to establish standardized procedures. The teachers were asked not to allow the subjects to get water, or use the restrooms, unless an emergency occurred during the five-minute transportation time preceding the mental testing sessions. Based on this training session each classroom teacher was given a procedure sheet (see Appendix C) and test schedule as shown in Table III. The same procedure was applied for each session.

During each physical exertion treatment session approximately fifty-four participants (two classes combined) were divided into seven lines and asked to perform a series of specific relay games (see Appendix D). The relays continued in a cycle, repeating themselves, as experimental sessions increased in duration.

Relay games were chosen for this study for the following reasons: (a) relays are representative of some elementary physical education programs; (b) relays can be performed in a continuous cycle; (c) relays can be standardized and controlled adequately for testing purposes; and (d) the subjects involved in this study were familiar with the relays through previous physical education experiences directed during the school year.
Pilot Study

A pilot study was conducted during March of 1977. The purposes of the pilot were to determine whether the five-minute transportation and preparation time from the physical exertion session to the mental ability task session was satisfactory and to determine if the physical exertion activities were functional at the second-grade level. The same school and classrooms were involved in this pilot study as were used for the mental ability task pilot reported earlier.

The five-minute interval was judged to be satisfactory. It was also concluded that five minutes was approximately the time interval used during the regularly scheduled day following a normal physical education lesson. This conclusion was based on information gathered after one week of observation.

The relay activities were considered adequate by the school district Elementary Physical Education Supervisor for use by second-grade students. The students were already familiar with the relays due to previous physical education instruction (2).

Analysis of the Data

The mental ability task served as the dependent variable. Of the original 106 subjects tested in the experimental study, ninety-five were selected for statistical analysis. Eleven sets of scores were discarded because of school and
treatment absences. If a subject missed a single treatment, he was not considered for statistical analysis.

Computer program ST017, designed for using the one-way analysis of variance with repeated measures, was used to determine if differences existed between the six experimental treatment means. When the interaction F-ratio was found to be significant, Dunnett's multiple comparison test was used. This test was designed to show where differences existed. The Dunnett multiple comparison test compared the pre-test mean (serving as the control) with the five post-test means.

To test for performance differences between males and females, computer program ST001, which is a program for one-way ANOVA using the mean difference option, was used. This study dealt with the statistical mean differences found in comparing male mean differences to female mean differences. The .05 level of significance was used throughout the investigation in conjunction with the statistical treatments.
CHAPTER BIBLIOGRAPHY


CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

The data used for analysis were derived from the mathematical mental ability task performance which represented mental performance after the four experimental physical exertion treatments and two control treatments. After the data were collected, analysis was made to determine whether significant differences existed among the six experimental treatments. Tested at the .05 level of significance, the six treatment means were subjected to the analysis of variance one-way design for repeated measures. The Dunnett multiple comparison test was used to determine which treatment means differed significantly when a significant F-ratio was found.

The Dunnett multiple comparison test is especially well-suited for making comparisons of a control treatment to each of the other treatments (1). The Dunnett test has the important property that the probability of a Type I error for any comparison does not exceed the level of significance specified in the analysis of variance for the overall hypothesis (1). Since the North Texas State University Computer Center could not compute a direct Dunnett statistical test, a Fisher's t-test was used in the computation.
of the treatment means while a Dunnett table of critical values was used to determine significance. Roscoe (1) states that the Dunnett multiple comparison test formula is the same as that used with the Fisher's *t*-test, but using Dunnett critical values.

A one-way analysis of variance with the mean difference option was used to test differences in performance between males and females. Use of this technique was called for in order to compare and analyze the male mean differences within treatments with female mean differences within treatments.

**Presentation of Data**

Based upon the results of the one-way analysis of variance for repeated measures, it was determined that a significant difference existed among the six experimental treatments. The main effect of treatments revealed an F-ratio of 21.77. The F-ratio associated with the degrees of freedom yielded a probability beyond .00001. To achieve significance the .05 level of significance was chosen and therefore, the main effects of the treatments were well beyond the acceptable values for significance (see Table IV).
## TABLE IV
### SUMMARY TABLE OF ONE-WAY ANALYSIS OF VARIANCE

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td>94</td>
<td>65576.621</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within Subjects</td>
<td>475</td>
<td>19760.167</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A (Treatments)</td>
<td>5</td>
<td>3715.756</td>
<td>743.151</td>
<td>21.770</td>
<td>0.00001</td>
</tr>
<tr>
<td>Residual</td>
<td>470</td>
<td>16044.411</td>
<td>34.137</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>569</td>
<td>85336.788</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A statistical difference was evidenced among the six experimental treatment means. With the highest possible score on each mental task being 72, the group mean was calculated and determined to be 34.02. See Table V for summary of treatment means.

## TABLE V
### SUMMARY OF GROUP MEANS AND TREATMENTS

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-test (no exertion)</td>
<td>32.72</td>
</tr>
<tr>
<td>20 Minute Treatment</td>
<td>31.71</td>
</tr>
<tr>
<td>30 Minute Treatment</td>
<td>32.08</td>
</tr>
<tr>
<td>40 Minute Treatment</td>
<td>34.21</td>
</tr>
<tr>
<td>50 Minute Treatment</td>
<td>39.34</td>
</tr>
<tr>
<td>Post-test (no exertion)</td>
<td>34.06</td>
</tr>
</tbody>
</table>
Since the interaction of the six experimental means was significant, Dunnett's multiple comparison test was used to find out where the differences occurred. Using the Fisher's t-test, the Dunnett table of values and degrees of freedom, a significant value for rejection or retention was established. The degrees of freedom were determined by calculating \( N-k \), which in this design represented 95-6 or 89. Using six treatment means, the critical Dunnett value of 2.28 determined significance at the .05 level. The specific purpose of the Dunnett test was to test the following treatment means with the pre-test acting as the control.

\[
M_1 = M_2 \quad M_1 = M_3 \quad M_1 = M_4 \quad M_1 = M_5 \quad M_1 = M_6
\]

The comparison of \( M_1 = M_6 \) was established as a study control. The pre-test (\( M_1 \)) and the post-test (\( M_6 \)) were compared for significance to find possible differences in non-physical exertion performances.

The Fisher's t-test technique was used to compute thirty-six pairwise comparisons. All possible comparisons were observed, although only five were used to test hypotheses in this study. The reasoning for this was to observe interaction between the six treatments so that more defined evidence could be found to support conclusions. Table VI is a summary of the Fisher's t-test used in making the Dunnett test comparisons.

The Dunnett test revealed the following results after comparison of the pre-test with the five post-test means. The
<table>
<thead>
<tr>
<th>Dunnett Comparison</th>
<th>Pre-test</th>
<th>20 min.</th>
<th>30 min.</th>
<th>40 min.</th>
<th>50 min.</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-test</td>
<td>0.0</td>
<td>1.192</td>
<td>0.745</td>
<td>-1.763</td>
<td>*-7.810</td>
<td>-1.589</td>
</tr>
<tr>
<td>20 min.</td>
<td>-1.192</td>
<td>0.0</td>
<td>-0.447</td>
<td>*-2.955</td>
<td>*-9.002</td>
<td>*-2.781</td>
</tr>
<tr>
<td>30 min.</td>
<td>-0.745</td>
<td>0.447</td>
<td>0.0</td>
<td>*2.508</td>
<td>*-8.555</td>
<td>*-2.234</td>
</tr>
<tr>
<td>40 min.</td>
<td>1.763</td>
<td>*2.955</td>
<td>*2.508</td>
<td>0.0</td>
<td>*-6.047</td>
<td>0.174</td>
</tr>
<tr>
<td>50 min.</td>
<td>*7.810</td>
<td>*9.002</td>
<td>*8.555</td>
<td>*6.047</td>
<td>0.0</td>
<td>*6.221</td>
</tr>
<tr>
<td>Post-test</td>
<td>1.589</td>
<td>*2.781</td>
<td>*2.334</td>
<td>-0.174</td>
<td>*-6.221</td>
<td>0.0</td>
</tr>
</tbody>
</table>

*Significant at .05 level.

-Second factor in the comparison had the greater mean score.
significant value for Dunnett 's multiple comparison test at the .05 level of significance with six treatment groups and an N of 95 was equal to 2.28. The only statistical difference was in the fifty-minute treatment, or group 5. As shown in Table V, the group mean for the fifty-minute treatment was 39.34 and the mean for the pre-test treatment was 32.72. Treatment 5 revealed a significant increase in mathematical performance as represented by the mathematical mental ability task used in this study.

**Hypothesis 1**

Hypothesis 1 stated that there would be no significant differences between the pre-test scores and the twenty minute post-test scores. The Dunnett multiple comparison test revealed that there was no statistical difference in the mean scores. The comparison revealed a value of 1.192 and a value of 2.28 or above was needed for rejection of the hypothesis; therefore hypothesis 1 was retained.

The twenty-minute treatment mean was 31.71 as compared to the pre-test mean of 32.72, in which no physical exertion was used as treatment. The twenty-minute mental performance produced lower scores than the pre-test treatment, and the lowest of the six treatment means (see Table V).

**Hypothesis 2**

Hypothesis 2 stated that there would be no significant differences between the pre-test scores and the
thirty-minute post-test scores. The Dunnett test comparison revealed a value of 0.745. To be significant, a value of 2.28 was needed; therefore the hypothesis was accepted. The thirty-minute treatment mean was also lower than the pre-test treatment mean.

Hypothesis 3
Hypothesis 3 stated that there would be no significant differences between the pre-test scores and the forty-minute post-test scores. The Dunnett multiple comparison revealed a comparison value of -1.763; therefore the hypothesis was retained. The forty-minute treatment did produce a higher mean performance score than did the pre-test treatment mean, although the difference was not significant.

Hypothesis 4
Hypothesis 4 stated that there would be no significant differences between the pre-test scores and the fifty-minute post-test scores. As shown in Table VII, the fifty-minute treatment mean, when compared to the pre-test mean, revealed an F-value of -7.810.

<table>
<thead>
<tr>
<th></th>
<th>Pre-Test</th>
<th>20-Minute</th>
<th>30-Minute</th>
<th>40-Minute</th>
<th>50-Minute</th>
<th>Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Test</td>
<td>1.192</td>
<td>0.745</td>
<td>-1.763</td>
<td>*-7.810</td>
<td>-1.589</td>
<td></td>
</tr>
</tbody>
</table>

*Significant at the .05 level.
A significant value for Dunnett's test at the .05 level of significance with six treatment groups and an N of 95 was equal to 2.28; therefore hypothesis 4 was rejected. The Dunnett test revealed that the fifty minute treatment group produced significantly higher scores on the mental ability task when compared to the pre-test scores. Table VI reveals data showing that the fifty minute treatment group achieved significantly higher scores than all treatment post-tests and pre-test.

**Hypothesis 5**

Hypothesis 5 stated that there would be no significant differences between the pre-test scores and the final post-test scores when the mental ability test was taken without induced physical exertion. The final post-test treatment which served as a control, produced a comparison value of 1.589. This value was not significant at the .05 level; therefore the hypothesis was retained.

**Hypothesis 6**

Hypothesis 6 stated that there would be no significant differences between males and females on the pre-test scores and the deviation from those scores by the post-test scores. The mean difference option of the one-way analysis of variance was used to test possible performance differences. The test and input variables that were used to accomplish the comparisons are shown in Table VIII.
The mean differences for the test variables among male and female groups are presented in Table IX.

### Table VIII

**Summary of Variable Explanation for Test of Mean Differences Between Scores**

<table>
<thead>
<tr>
<th>Test Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Variable</td>
<td>Minus 20 min.</td>
<td>Minus 30 min.</td>
<td>Minus 40 min.</td>
<td>Minus 50 min.</td>
<td>Post-test Minus Pre-test</td>
</tr>
<tr>
<td>Pre-test</td>
<td></td>
<td>Pre-test</td>
<td>Pre-test</td>
<td>Pre-test</td>
<td></td>
</tr>
</tbody>
</table>

### Table IX

**Summary of Mean Differences for Male and Female Groups**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Number of Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>-1.525</td>
<td>8.208</td>
<td>59</td>
</tr>
<tr>
<td>2</td>
<td>-1.864</td>
<td>8.679</td>
<td>59</td>
</tr>
<tr>
<td>3</td>
<td>0.068</td>
<td>10.279</td>
<td>59</td>
</tr>
<tr>
<td>4</td>
<td>5.814</td>
<td>8.055</td>
<td>59</td>
</tr>
<tr>
<td>5</td>
<td>1.254</td>
<td>8.127</td>
<td>59</td>
</tr>
<tr>
<td>Females</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>-0.167</td>
<td>7.861</td>
<td>36</td>
</tr>
<tr>
<td>2</td>
<td>0.278</td>
<td>8.674</td>
<td>36</td>
</tr>
<tr>
<td>3</td>
<td>3.833</td>
<td>9.151</td>
<td>36</td>
</tr>
<tr>
<td>4</td>
<td>7.944</td>
<td>9.435</td>
<td>36</td>
</tr>
<tr>
<td>5</td>
<td>1.500</td>
<td>8.624</td>
<td>36</td>
</tr>
</tbody>
</table>
A comparison of the male and female mean differences was accomplished through a one-way analysis of variance design. The one-way design revealed that no significant differences existed in the comparison of male and female mean differences. Table X presents data pertaining to the results of the one-way analysis of variance on mean differences of male and female groups.

Discussion of the Findings

This investigation was developed within the confines of the expressed purposes and hypotheses. The data collected, as outlined in the procedures, were analyzed and the results used in determining the acceptance or rejection of the stated hypotheses.

Purpose 1

The first purpose of the study was to gain further information concerning the effects of physical exertion on a mathematical mental ability task administered to second graders. Included as part of this purpose was the evaluation of each of four durations (twenty, thirty, forty, and fifty minutes) used to induce physical exertion. It was hypothesized that there would be no significant differences between the pre-test scores and the five post-test scores. The results of the one-way analysis of variance and the Dunnett multiple comparison revealed that a significant difference existed only between the pre-test and the fifty-minute treatment (see
TABLE X
SUMMARY OF THE ONE-WAY ANALYSIS OF VARIANCE
COMPARING MEAN DIFFERENCES

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>Degrees of Freedom</th>
<th>Variance Estimate</th>
<th>F Ratio</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between</td>
<td>41.278</td>
<td>1.</td>
<td>41.278</td>
<td>0.633</td>
<td>0.429</td>
</tr>
<tr>
<td>Within</td>
<td>6069.712</td>
<td>93.</td>
<td>65.266</td>
<td>. .</td>
<td>. .</td>
</tr>
<tr>
<td>Total</td>
<td>6110.990</td>
<td>94.</td>
<td>. .</td>
<td>. .</td>
<td>. .</td>
</tr>
<tr>
<td>Variable 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between</td>
<td>47.934</td>
<td>1.</td>
<td>47.934</td>
<td>0.637</td>
<td>0.427</td>
</tr>
<tr>
<td>Within</td>
<td>7002.171</td>
<td>93.</td>
<td>75.292</td>
<td>. .</td>
<td>. .</td>
</tr>
<tr>
<td>Total</td>
<td>7050.105</td>
<td>94.</td>
<td>. .</td>
<td>. .</td>
<td>. .</td>
</tr>
<tr>
<td>Variable 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between</td>
<td>317.019</td>
<td>1.</td>
<td>317.019</td>
<td>3.255</td>
<td>0.075</td>
</tr>
<tr>
<td>Within</td>
<td>9058.729</td>
<td>93.</td>
<td>97.406</td>
<td>. .</td>
<td>. .</td>
</tr>
<tr>
<td>Total</td>
<td>9375.747</td>
<td>94.</td>
<td>. .</td>
<td>. .</td>
<td>. .</td>
</tr>
<tr>
<td>Variable 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between</td>
<td>101.520</td>
<td>1.</td>
<td>101.520</td>
<td>1.373</td>
<td>0.244</td>
</tr>
<tr>
<td>Within</td>
<td>6878.838</td>
<td>93.</td>
<td>73.966</td>
<td>. .</td>
<td>. .</td>
</tr>
<tr>
<td>Total</td>
<td>6980.358</td>
<td>94.</td>
<td>. .</td>
<td>. .</td>
<td>. .</td>
</tr>
<tr>
<td>Variable 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between</td>
<td>1.350</td>
<td>1.</td>
<td>1.350</td>
<td>0.020</td>
<td>0.902</td>
</tr>
<tr>
<td>Within</td>
<td>6434.186</td>
<td>93.</td>
<td>69.185</td>
<td>. .</td>
<td>. .</td>
</tr>
<tr>
<td>Total</td>
<td>6435.537</td>
<td>94.</td>
<td>. .</td>
<td>. .</td>
<td>. .</td>
</tr>
</tbody>
</table>
Table VII). The subjects achieved significantly higher scores after fifty minutes of prolonged physical exertion as compared to performances on the pre-test. The fifty-minute treatment group also performed significantly higher on the mental ability task when compared to the four other post-tests (see Table VI).

Table V reveals some evidence that a trend in mental performance scores existed. The twenty-minute treatment produced a mean score lower than the pre-test, with each increased duration producing a gradual increase on mental task performance.

There was no significant difference between the pre-test and final post-test scores which established each subject as his own control. It can be assumed that no significant improvement occurred during the course of this project.

The fact that the subjects performed significantly higher after fifty minutes of prolonged physical exertion supports previous research evidence (1, 2, 3). Davey (1) concluded in studies during 1972 and 1973 that physical exertion affects mental performance by raising the level of arousal. He found that a sub-maximal amount of physical exertion improved mental performance on an attention-type test among adult subjects.

Marteniuk (3) reported that arousal can be increased through physical exertion, and that it not only facilitates motor performance, but also increases cognitive performance
skill. He also concluded that physical exertion had a positive influence on both mental and motor performance. Marteniuk and Davey referred to this process as the inverted-u-relationship. Maximum performance, as outlined in this relationship, is the result of an optimal degree of arousal, which is usually moderate in intensity.

Duffy (2) referred to this same process as the activation theory. He also hypothesized that there was an optimal state of the central nervous system underlying maximum performance.

The results of this study revealed that subjects' performance increased after forty- and fifty-minute periods of physical exertion; the fifty-minute treatment represented a significant increase. The forty- and fifty-minute treatments were both significantly higher than the twenty- and thirty-minute treatments.

The twenty- and thirty-minute treatment scores were both lower than the pre-test scores. It seems reasonable to assume that optimal performance arousal occurred at the forty- and fifty-minute treatment levels, but not at the twenty- and thirty-minute treatment levels.

Another possible explanation for the differences between the twenty- and thirty-minute treatments and the pre-test scores may be the psychological state of the subjects. Being adapted to physical exertion bouts of regular physical education class sessions of thirty minutes may have been a factor.
that affected results in the twenty- and thirty-minute treatments. The students may have been psychologically excited by the activity during the twenty- and thirty-minute treatments and after returning to the classroom could not relax enough for participation in an immediate mental task. Arousal as produced by twenty- and thirty-minutes of physical exertion may have left the subjects excited, thus not enabling them to concentrate on immediate mental performance. The forty- and fifty-minute levels of physical exertion with which the subjects did not have previous experience, may have been enough to relax them, thus resulting in more efficient performance on the mental ability task.

Purposes 2 and 3

The second and third purposes of the study were to determine if students were performing under possibly debilitating or stimulating conditions by being asked to perform immediate classroom tasks after four different periods of physical exertion. The results of the one-way analysis of variance and the Dunnett multiple comparison test revealed that none of the physical exertion treatments were significantly debilitating (see Table VII). The results also revealed that the fifty-minute physical exertion treatment had a positive effect on the performance of the mathematical mental ability task.
Purpose 4

The fourth purpose of this investigation was to determine whether males or females were more affected by experimentally induced physical exertion as it relates to immediate classroom performance on a mathematical task. The results of the one-way analysis of variance revealed that there were no significant differences between males and females (see Table X).
CHAPTER BIBLIOGRAPHY


CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The problem of this investigation was to analyze the effects of induced physical exertion on a mathematical mental ability task administered to second-grade students. The study was based on the need to investigate the relationship between physical exertion and mental performance in elementary school children.

The following purposes were proposed to further clarify the study:

1. To gain further information concerning the effects of physical exertion on a mathematical mental ability task among second graders, and to evaluate each of four induced physical exertion treatments (twenty, thirty, forty, and fifty minutes) used in this study;

2. To determine if students are performing under possibly debilitating conditions when asked to perform immediate classroom mental tasks after periods of physical exertion;

3. To determine if students are stimulated by certain levels of physical exertion and improve mental performance on certain mathematical tasks;
4. To determine whether males or females are more affected by experimentally induced physical exertion as it relates to immediate classroom performance of a mathematical task.

The procedure for collecting data included selection of the sample, research design, testing procedures, and procedures for treating the data. One hundred and six second-grade students were selected from a single elementary school during the spring of 1977. During the students' regularly scheduled physical education class periods they were administered four experimental treatments of induced physical exertion. The treatments were durations of activities lasting twenty, thirty, forty, and fifty minutes. The movement activities performed during the physical exertion sessions were specific relay game activities that were performed in a continuous cycle as the duration of the sessions got longer.

The students were assigned six mathematical mental ability tasks. Four of the tasks were performed five minutes after the finish of each of the four physical exertion sessions. The first and last mental task sessions were performed without induced physical exertion and served as controls. Each mental ability task was composed of thirty-six first-grade level problems that required adding and subtracting with no borrowing or carrying functions. The students were given two minutes to complete each of the six mental tasks.
Pilot studies were conducted to formulate procedures for the mental ability tasks and the physical exertion sessions.

Six hypotheses were formulated. The first five hypotheses stated that there would be no significant differences between the pre-test scores and each of the five post-test scores. The sixth hypothesis stated that there would be no significant difference between the males and females on the pre-test scores and the deviation from those scores by the post-test scores. The one-way analysis of variance using the mean difference option was utilized to test the sixth hypothesis. Each hypothesis was tested at the .05 level of significance.

The one-way analysis of variance for repeated measures was used to establish if differences existed between the six treatments of the mental ability tasks. When a significant F was established, the Dunnett multiple comparison test was used to find out where the significant differences existed.

Review of Findings

In Chapter IV, where each of the six hypotheses were considered separately, the following results were reported.

The results of the one-way analysis of variance for repeated measures confirmed that significant differences did exist among the six treatments. The Dunnett multiple comparison test was used to determine which treatment means
differed significantly when a significant F-ratio was found. The Dunnett test revealed, after comparing the pre-test with the five post-test means, that the only statistical difference existed in the comparison of the pre-test scores and the fifty minute scores. The fifty minute treatment had produced significantly higher scores on the mental ability task when compared to all the other treatments. The Dunnett test also revealed that there were no significant differences between the pre-test control and the final post-test control.

The one-way analysis of variance with mean difference option revealed that no significant differences existed in the comparison of male and female mean differences.

There were two possible explanations cited for the results of the Dunnett test. Davey (1), Duffy (2), and Marteniuk (3) have reported evidence to support the findings of this study. All three researchers have concluded, as a result of their studies, that physical exertion can facilitate mental performance. They explained the process involved in such results as the inverted-u-relationship theory. The theory hypothesizes that physical exertion affects mental performance by raising the level of arousal. Marteniuk stated, while referring to the inverted-u-relationship, that physical exertion facilitates cognitive skills involved in information processing and mental performance.

Another explanation involved the assumed ability of the students to relax after unusual bouts of physical exertion.
Since the students had performed physical education activities regularly throughout the year in thirty-minute bouts, it was hypothesized that the forty- and fifty-minute treatments and the additional exertion allowed them to relax and perform immediate mental tasks more efficiently than the twenty- and thirty-minute treatments.

The results of the twenty- and thirty-minute treatments revealed that the mental scores were lower than the pre-test scores. Perhaps this was due to student excitement and desire for more activity. The desire or arousal may have interfered with the students' ability to attend and perform immediate mental tasks.

Conclusions

Based upon the procedures utilized for data collection, the statistical treatments of that data, the stated limitations and the major findings of the study, the following conclusions merit consideration.

1. Certain levels of physical exertion have a positive effect on the mental performance of second graders when compared to scores achieved without prior induced physical exertion.

2. The results of performance after physical exertion are not significantly different between male and female second graders when comparing mean differences for each sex.
3. Prolonged physical exertion, as induced by relay games for up to fifty minutes, will not significantly debilitate mental performance on certain mathematical tasks.

4. The subjects achieved higher mathematical scores after fifty minutes of prolonged physical exertion as compared to durations of twenty, thirty, forty minutes and two sessions with no induced physical exertion.

Recommendations

The results of this investigation indicate a need for further research in the areas suggested below.

1. Other elementary-grade levels need to be investigated in the area of physical exertion and mental performance.

2. The effects of physical exertion as occurs during free play periods should be investigated.

3. An extension of this study should be conducted to determine the effects of physical exertion and mental performance beyond the fifty-minute duration period.

4. An investigation should be conducted to determine effective rest intervals needed between bouts of physical exertion and immediate mental tasks.

5. The pre-school aged child should be studied to determine mental performance levels after physical exertion.

6. A study should be conducted to gain more information concerning the time of day that physical exertion bouts should be scheduled in the public schools.
7. The effects of delayed bouts of physical exertion on mental performance should be investigated.
CHAPTER BIBLIOGRAPHY


## TEST A

Name ________________________________

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>2</td>
<td>50</td>
<td>97</td>
<td>1</td>
<td>44</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>+2</td>
<td>-83</td>
<td>+2</td>
<td>+43</td>
<td>-20</td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>4</td>
<td>25</td>
<td>52</td>
<td>2</td>
<td>61</td>
<td></td>
</tr>
<tr>
<td>-16</td>
<td>+4</td>
<td>+71</td>
<td>-32</td>
<td>+4</td>
<td>+34</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>79</td>
<td>2</td>
<td>89</td>
<td>3</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>-20</td>
<td>-29</td>
<td>+3</td>
<td>+10</td>
<td>+3</td>
<td>+32</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>20</td>
<td>90</td>
<td>40</td>
<td>62</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>+2</td>
<td>-60</td>
<td>-10</td>
<td>+34</td>
<td>+3</td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>28</td>
<td>65</td>
<td>2</td>
<td>21</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>-31</td>
<td>+51</td>
<td>-34</td>
<td>+3</td>
<td>+35</td>
<td>+0</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>1</td>
<td>99</td>
<td>87</td>
<td>0</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>+29</td>
<td>+4</td>
<td>-36</td>
<td>-22</td>
<td>+1</td>
<td>+68</td>
<td></td>
</tr>
</tbody>
</table>
### TEST B

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>61</td>
<td>28</td>
<td>9</td>
<td>1</td>
<td>60</td>
<td>0</td>
</tr>
<tr>
<td>-31</td>
<td>+35</td>
<td>-14</td>
<td>+2</td>
<td>+3</td>
<td>+20</td>
<td></td>
</tr>
</tbody>
</table>

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>89</td>
<td>76</td>
<td>8</td>
<td>70</td>
<td>97</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>-14</td>
<td>+22</td>
<td>+7</td>
<td>+29</td>
<td>-46</td>
<td>+4</td>
<td></td>
</tr>
</tbody>
</table>

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>97</td>
<td>44</td>
<td>2</td>
<td>75</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>+29</td>
<td>-83</td>
<td>-40</td>
<td>+8</td>
<td>-34</td>
<td>+1</td>
<td></td>
</tr>
</tbody>
</table>

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>68</td>
<td>47</td>
<td>90</td>
<td>53</td>
<td>3</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>-20</td>
<td>-16</td>
<td>+10</td>
<td>+36</td>
<td>+3</td>
<td>+0</td>
<td></td>
</tr>
</tbody>
</table>

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>6</td>
<td>66</td>
<td>5</td>
<td>96</td>
<td>87</td>
<td>5</td>
</tr>
<tr>
<td>+23</td>
<td>+2</td>
<td>+30</td>
<td>+3</td>
<td>-16</td>
<td>-40</td>
<td></td>
</tr>
</tbody>
</table>

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>52</td>
<td>1</td>
<td>83</td>
<td>23</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>-20</td>
<td>-30</td>
<td>+3</td>
<td>+16</td>
<td>+36</td>
<td>+3</td>
<td></td>
</tr>
</tbody>
</table>
## TEST C

<table>
<thead>
<tr>
<th>Name</th>
<th>68</th>
<th>50</th>
<th>44</th>
<th>58</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-45</td>
<td>+30</td>
<td>+23</td>
<td>-46</td>
<td>+9</td>
<td>+7</td>
</tr>
<tr>
<td>57</td>
<td>+32</td>
<td>-74</td>
<td>+26</td>
<td>-25</td>
<td>+3</td>
<td>+1</td>
</tr>
<tr>
<td>99</td>
<td>+6</td>
<td>-40</td>
<td>+15</td>
<td>+20</td>
<td>+8</td>
<td></td>
</tr>
<tr>
<td>65</td>
<td>+13</td>
<td>-58</td>
<td>+6</td>
<td>+13</td>
<td>-62</td>
<td>+4</td>
</tr>
<tr>
<td>40</td>
<td>+10</td>
<td>+2</td>
<td>-60</td>
<td>+4</td>
<td>+36</td>
<td>-56</td>
</tr>
<tr>
<td>7</td>
<td>6</td>
<td>56</td>
<td>77</td>
<td>2</td>
<td>77</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>+1</td>
<td>-46</td>
<td>+22</td>
<td>+5</td>
<td>-36</td>
<td>+33</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>42</td>
<td>61</td>
<td>95</td>
<td>40</td>
<td>2</td>
</tr>
<tr>
<td>---</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>-----</td>
</tr>
<tr>
<td>+2</td>
<td>+27</td>
<td>-30</td>
<td>-83</td>
<td>+47</td>
<td>+7</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>76</th>
<th>29</th>
<th>5</th>
<th>6</th>
<th>29</th>
<th>46</th>
</tr>
</thead>
<tbody>
<tr>
<td>-24</td>
<td>+50</td>
<td>+0</td>
<td>+5</td>
<td>-25</td>
<td>+53</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>4</th>
<th>37</th>
<th>77</th>
<th>89</th>
<th>63</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>+4</td>
<td>+40</td>
<td>-46</td>
<td>-79</td>
<td>+24</td>
<td>+3</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>56</th>
<th>0</th>
<th>93</th>
<th>88</th>
<th>56</th>
</tr>
</thead>
<tbody>
<tr>
<td>+9</td>
<td>+33</td>
<td>+6</td>
<td>-70</td>
<td>-10</td>
<td>+10</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>31</th>
<th>19</th>
<th>45</th>
<th>2</th>
<th>99</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>+28</td>
<td>-10</td>
<td>+22</td>
<td>+3</td>
<td>-76</td>
<td>+6</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>66</th>
<th>60</th>
<th>8</th>
<th>86</th>
<th>55</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>-63</td>
<td>+35</td>
<td>+2</td>
<td>-36</td>
<td>+10</td>
<td>+4</td>
<td></td>
</tr>
</tbody>
</table>
## TEST E

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
<td>40</td>
<td>2</td>
<td>78</td>
<td>28</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>+43</td>
<td>-30</td>
<td>+5</td>
<td>-54</td>
<td>+50</td>
<td>+3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>86</td>
<td>8</td>
<td>55</td>
<td>20</td>
<td>7</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>-62</td>
<td>+1</td>
<td>-23</td>
<td>+15</td>
<td>+1</td>
<td>+40</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>67</td>
<td>2</td>
<td>44</td>
<td>53</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>+11</td>
<td>-34</td>
<td>+6</td>
<td>-22</td>
<td>+41</td>
<td>+2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>89</td>
<td>53</td>
<td>3</td>
<td>69</td>
<td></td>
</tr>
<tr>
<td>+2</td>
<td>+36</td>
<td>-72</td>
<td>+41</td>
<td>+3</td>
<td>-47</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>55</td>
<td>4</td>
<td>66</td>
<td>21</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>+30</td>
<td>-30</td>
<td>+3</td>
<td>-15</td>
<td>+21</td>
<td>+2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>76</td>
<td>8</td>
<td>10</td>
<td>90</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>-17</td>
<td>-52</td>
<td>+0</td>
<td>+67</td>
<td>+10</td>
<td>+1</td>
<td></td>
</tr>
</tbody>
</table>
## TEST F

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>53</td>
<td>36</td>
<td>0</td>
<td>7</td>
<td>72</td>
<td>+30</td>
</tr>
<tr>
<td>3</td>
<td>37</td>
<td>69</td>
<td>58</td>
<td>40</td>
<td>5</td>
<td>+2</td>
</tr>
<tr>
<td>90</td>
<td>0</td>
<td>86</td>
<td>85</td>
<td>0</td>
<td>35</td>
<td>-10</td>
</tr>
<tr>
<td>61</td>
<td>54</td>
<td>6</td>
<td>79</td>
<td>44</td>
<td>9</td>
<td>+17</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>89</td>
<td>70</td>
<td>7</td>
<td>80</td>
<td>+3</td>
</tr>
<tr>
<td>20</td>
<td>37</td>
<td>7</td>
<td>54</td>
<td>9</td>
<td>66</td>
<td>+20</td>
</tr>
</tbody>
</table>

Name:
APPENDIX B
## Score-Information Sheet

**Test Group**

**Sex**

<table>
<thead>
<tr>
<th>Name</th>
<th>Pre-test</th>
<th>20 min.</th>
<th>30 min.</th>
<th>40 min.</th>
<th>50 min.</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CLASSROOM TEACHER PROCEDURES

SHEET

1. Check dates and times on schedule sheet for your testing period.
2. Make sure that you have the proper test.
3. The test will be brought to you the morning preceding your test period.
4. Bring students to gymnasium door.
5. Pick up subjects at exact time, and no later!
6. You will have five minutes to proceed from the gymnasium to your classroom and the start of the mental ability testing.
7. Take the full five minutes for preparation; do not start early!
8. Students should not be permitted to get a drink or use the restroom until the test is over.
9. The students have two minutes to complete the mental task. Make sure that you have a stopwatch.
10. Have the students write their names on each test.
11. Give the subjects the following instructions before each test:
   a. "Students, you are going to do a math exercise in which you will have two minutes to work as many problems as possible."
b. "I will tell you when to stop. Do not raise your hands for any questions."

c. "Start with the first problem and work from left to right."

12. After two minutes, stop the subjects and pick up tests. Collect data separately (males and females) and paper clip together.

13. Identify your test group with your code letter as shown on the testing schedule sheet.

14. Place tests in the researcher's box the same day.
DESCRIPTION OF THE RELAY ACTIVITIES (2)

The relay activities were administered by the researcher. The movements were of a relay type and conducted in a continuous cycle. The cycle consisted of the following relays: (a) running relay, (b) overhead relay, (c) underleg relay, (d) over and under relay, and (e) side relay. The relay movements were used during the experimental period of twenty, thirty, forty, and fifty minute durations.

Subjects were lined up in straight line relay formation. Seven lines were formed with seven to eight participants in each line. Each line leader had a size seven red playground utility ball. The lines performed the following relay games.

(a) Running relay--the line leader ran thirty-seven feet forward and touched a marked line with his feet. He returned thirty-seven feet to the original starting line. The next person in the line took a hand-off from the leader and then ran the same distance. After each participant handed off the ball to the lead person, he went to the end of the line. When the original leader received the hand-off and was at the front of the line again, the relay was completed.

(b) Overhead relay--still standing in line formation and looking straight ahead, the leader, on the sound of the whistle, passed the ball overhead to the rear with both hands. The next person took the ball and
repeated the process. When the ball reached the last subject at the end of the line, he ran to the front of the line, turned with his back to the next person and repeated the relay. The relay was completed when the original leader was at the front of the line again.

(c) Underleg relay—the underleg relay was similar to the overhead relay, only the subjects passed the ball between the legs and worked it from the front of the line to the last person in the line. The last person ran to the front of the line and repeated the relay by passing the ball between the legs. As in all the relays, sure-handedness was stressed, for the ball should never touch the floor. The relay was completed when the original leader was at the front of the line again.

(d) Over and under relay—this was a combination of the overhead and underleg relays. The leader started off by passing the ball overhead and behind him. The next person grabbed the ball and passed it between the legs to the next person. The relay was continued using alternate moves. The exercise was completed when the original leader reached the head of the line once again.

(e) Side relay—the side relay was performed by allowing the subject to pass the ball to the person
behind him using a turn-around style of his own choice. Just as in the other relays, the ball was moved to the last person in line using the same style. The last person in the line, after receiving the ball, ran to the front of the line, turned with his back to the second person in line and began the relay over again. The relay was completed when the original leader reached the front of the line for the second time.

Each student was instructed in the performance of each relay before the experimental sessions began. This procedure eliminated pre-treatment verbal instruction on performance of each relay. The names of the relays were stated only during the physical exertion sessions. All relays were started and stopped with the use of a whistle. A replacement instructor for the experimental sessions was selected and briefed thoroughly in case of absence by the original instructor.

A teaching aide was available and used only to help with the instruction when new students were enrolled. The aide instructed the new students in the performance of the relays and then positioned them in the relay lines with the rest of the experimental group. The aide had no other function while the experimental sessions were taking place.
BIBLIOGRAPHY

Books


Articles


Alderman, R. B., "Influences of Local Fatigue on Speed and Accuracy in Motor Learning," *Research Quarterly*, XXXVI (1965), 131-140.


