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ABSTRACT

This study was designed (1) to investigate the relationship between physical exertion and mental performance in elementary school children and (2) to determine if male or female mental performances are more affected by physical exertion. A total of 95 second graders participated in six treatments of induced physical exertion during their regularly scheduled physical education classes. The six experimental treatments consisted of a pre-test and five post-tests. The pre-test and final post-test were used as controls in which the subjects performed the mental task with no prior induced physical exertion. The four induced physical exertion treatments lasted 20, 30, 40, and 50 minutes. After each exertion session, the classroom teachers administered a mathematical mental test consisting of 36 first grade level problems. Results indicated that the subjects performed significantly better on the math problems after 50 minutes of physical exertion than after no exertion. Testing also revealed no significant differences between male and female mean difference scores. (Author/JMB)

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PHYSICAL EXERTION AND IMMEDIATE CLASSROOM MENTAL PERFORMANCE  
AMONG ELEMENTARY SCHOOL CHILDREN

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Abstract

The two-fold purpose of this study was (1) to investigate the relationship between physical exertion and mental performance in elementary school children and (2) to determine if male or female mental performances are more affected by physical exertion. Second grade students (N=106) served as subjects and were administered six treatments of induced physical exertion during their regularly scheduled physical education classes. The sessions lasted as follows: pre-test (no exertion), twenty, thirty, forty, fifty-minutes, and final post-test (no exertion).

Five minutes after the finish of each treatment, the subjects were administered a mathematical computation test. Results indicated that the only significant difference when comparing the pre-test (control) to the five post-test means was the fifty-minute treatment. The subjects achieved higher scores after fifty minutes of physical exertion. Testing also revealed no significant differences between male and female mean difference scores.

In 1973, Davey (1) conducted a study to determine the effects of physical exertion on mental performance using adult subjects. After the subjects pedalled a bicycle ergometer for varying periods of time, they were admini-

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tested the Brown and Paulton Test of Attention. Davey concluded that a submaximal amount of physical exertion improved mental performances. Davey based his conclusions on the inverted-u-relationship theory, which suggests that physical exertion affects mental performance by raising the level of arousal. Duffy (2) and Marteniuk (4) suggested evidence that supports Davey's findings. Marteniuk reported that arousal can be increased through physical exertion and it not only facilitates motor performances, but also increases cognitive skills (4:40).

Ellingstad and Heimstra (3) 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 or increase on the multiplication task.

Evidence can be found supporting a number of exertion studies showing increases in mental performance; however, few if any studies have utilized elementary school children as subjects. Elementary physical education class durations are usually based on effective scheduling or state recommendation, but few class durations are based on researched information pertaining to student capabilities and later classroom performance. The aim of this study was to observe the effects of physical exertion on children in an elementary school setting.

#### Procedures

Subjects were 106 second grade students selected from a single elementary school in north central Texas. Using a repeated measures with equivalent materials design and four intact second grade classes, the subjects were administered six experimental treatments during their regularly scheduled physical education classes. The regular physical education schedule

grouped the four intact second grade classes into two groups with two classes in each group. The six experimental treatments were administered at the same time daily (after the lunch hour) and were conducted on an every other day schedule. The students were not told that they were participating in a research study.

The six experimental treatments consisted of a pre-test and five post-tests. The pre-test and final post-test were used as controls in which the subjects performed the mental task only (no prior induced physical exertion). The four induced physical exertion treatments lasted twenty, thirty, forty, and fifty-minutes. Five, ball relay activities were performed using a cyclical method during the induced-exertion treatments. As the induced treatments got longer, the cycle continued until the session was completed. After each non-stop physical exertion session, the subjects were given five minutes to return to their individual classrooms and prepare for the mathematical mental task. The classroom teacher led her own students back to their room and did not allow restroom or water breaks during the experimental sessions. Exactly five minutes after each exertion session, the classroom teacher administered the mathematical mental test.

Each test consisted of thirty-six first grade level problems in which no borrowing or carrying functions were required. These types of problems were selected after a pilot study (using three different schools with an  $N$  of 90) revealed that some of the students tested could not work problems using borrowing and carrying functions. Each mental task was equivalent in difficulty, but not identical. Three different types of problems were used. Each line (six lines were used) contained two of each type of problem. Random number and order changes were performed on each set of tests and problems. During the pilot study the tests were statistically tested for

reliability using the Pearson Product Moment Correlation. The ninety pilot subjects were administered all six mental ability tests on MWF for two weeks. One test was administered each day during the morning and before any physical exertion period. The main reason for this reliability testing was to determine if practice and time would increase the math scores over a two week period (the same time proposed and used during the main study). The results of the correlation testing revealed the following paired correlations: Test 1 and 2  $r=.94$ , Test 1 and 3  $r=.97$ , Test 1 and 4  $r=.96$ , Test 1 and 5  $r=.96$ , Test 1 and 6  $r=.94$ . These comparisons were based on the final proposed statistical design where by the pre-test scores (control) were used as a base and significance was determined as each test after exertion differed from this set of scores. ~~It was~~ concluded after the pilot study that practice over a two week period was not a significant factor in score differences.

During the pilot and original study the students were given two minutes to complete each mental test. None of the students completed all of the thirty-six problems within the two minute limit, however, all the subjects completed at least two problems correctly. Each problem was worth two points.

The mathematical test scores served as the dependent variable and were statistically analyzed. The basis of the statistical analysis was to compare the deviations of each post-test from the pre-test (control).

### Results

Of the 106 subjects who started the study, 95 were used in the final statistical analysis. Eleven were disqualified because of absences. A one-way ANOVA for repeated measures was used to test for significant differences

among the six experimental treatments (Table 1). When the one-way ANOVA revealed that a difference did exist, the Dunnett multiple comparison test found that the only significant difference when comparing the pre-test to the five post-tests, was the fifty-minute treatment (Table 2). The fifty-minute treatment indicated significantly higher scores when compared to the pre-test and the four post-tests. Table 3 reveals information pertaining to the treatment means, standard deviations and number of subjects per treatment. The pre-test and final post-test, acting as controls, revealed no significant difference.

The mean difference option of the one-way ANOVA was used to test possible performance differences between males and females. The test and input variables that were used to accomplish the comparisons are shown in Table 4. The mean differences for the test variables among male and female groups are presented in Table 5. The one-way ANOVA revealed that no significant differences existed in the comparison of male and female mean differences. Table 6 presents data pertaining to the results of the one-way ANOVA on mean differences of male and female groups.

### Discussion

The results support the findings of Davey (1) and also suggest evidence to support the theories of Duffy (2) and Marteniuk (4). The results of this study revealed that a certain level of induced physical exertion (fifty-minutes) had a positive influence on mental performance. None of the induced physical exertion treatments had a significant debilitating effect on mental performance. When considering the inverted-u-relationship, it would appear from these results that a certain amount of arousal, as shown at the twenty and thirty-minute treatments, was not stimulating enough to produce higher mental performance scores when compared to the pre-test (Table 3).

The fact that some elementary physical education classes and free play periods for second grade children are scheduled for twenty and thirty-minute bouts, may lead us to some new areas of thought as to what amount of exertion a child can cope with during the school day.

Another possible explanation for the findings may involve the ability of the students to relax after unusual bouts of physical exertion. The students were adapted to exertion bouts lasting up to thirty-minutes. The experimental treatments of forty and fifty-minutes may have exerted the students to a point of relaxation rather than arousal. The relaxation of the body after exertion may have stimulated the students to concentrate on mental functions rather than arouse them for more activity. This may explain the decrease in performance at the twenty and thirty-minute treatment levels. The students, being adapted to such bouts, may have only been aroused by the exertion and psychologically were excited for more activity. This excitement, transferred back to the classroom, may have debilitated the students ability to perform immediate mental functions in a normal manner.

### Conclusions

Based upon the procedures, limitations, and major findings of the study, the following conclusions merit consideration:

1. Certain levels of physical exertion as induced by relay-type activities, have a positive effect on the mental performance of second grade students.
2. The results of performance after induced physical exertion are not significantly different between male and female second graders when comparing mean differences.

3. Prolonged physical exertion as induced by relay games for up to fifty-minutes, will not significantly debilitate immediate mental performance on certain mathematical tests.

## References

1. Davey, C.P. "Physical exertion and mental performance." Ergonomics, 1957, 16, 595-599.
2. Duffy, E. Activation and behavior. New York: Wiley, 1962.
3. Ellingstad, V.S., and Heimstra, N.W. "Performance changes during sustained operation of a complex psychomotor task." Ergonomics, 1971, 693-705.
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Table 1-SUMMARY TABLE OF ONE-WAY ANOVA FOR SIX TREATMENTS

Source	df	ss	Ms	F
Between Subject	94	65576.62		
Within Subjects	475	19760.17		
A (treatments)	5	3715.76	743.15	21.77*
Residual	470	16044.41	34.14	
Total	569	85336.79		

\*significant at .05 level

Table 2-SUMMARY OF THE FISHER'S T AND DUNNETT TEST

	Pre	20min	30min	40min	50min	post
Pre	0	1.192	0.745	1.763	7.810*	1.589
20 min	1.192	0	0.447	2.955*	9.002*	2.781*
30 min	0.745	0.447	0	2.508*	8.555*	2.334*
40 min	1.763	2.955*	2.508*	0	6.047*	0.174
50 min	7.810*	9.002*	8.555*	6.047*	0	6.221*
Post	1.589	2.781*	2.334*	0.174	6.221*	0

\*significant at the .05 level  
Dunnnett value of 2.28

Table 3-SUMMARY OF SIX TREATMENT MEANS, STANDARD DEVIATIONS AND N

Treatment	Mean	SD	N
Pre-test	32.72	9.23	106
20 min	31.71	9.85	106
30 min	32.08	8.65	104
40 min	34.21	8.55	101
50 min	39.34	7.32	103
Post-test	34.06	8.34	105
Group Mean=34.02			

Table 4-SUMMARY OF VARIABLE EXPLANATION FOR TEST OF MEAN DIFFERENCES

Test Variable	1	2	3	4	5
Input Variable	20 min. Minus Pre-test	30 min. Minus Pre-test	40 min. Minus Pre-test	50 min. Minus Pre-test	Post-test Minus Pre-test

Table 5-SUMMARY OF MEAN DIFFERENCES FOR MALE AND FEMALE GROUPS

	Variable	Mean	Standard Deviation	Number of Observations
Males	1	-1.525	8.208	59
	2	-1.864	8.679	59
	3	0.068	10.279	59
	4	5.814	8.055	59
	5	1.254	8.127	59
Females	1	-0.167	7.861	36
	2	0.278	8.674	36
	3	3.833	9.151	36
	4	7.944	9.435	36
	5	1.500	8.624	36

Table 6-SUMMARY OF ONE-WAY ANOVA COMPARING MEAN DIFFERENCES

Source	Sum of Squares	Degrees of Freedom	Variance Estimate	F Ratio	P
Variable 1					
Between	41.278	1.	41.278	0.633	0.429
Within	6069.712	93.	65.266		
Total	6110.990	94.			
Variable 2					
Between	47.934	1.	47.934	0.637	0.427
Within	7002.171	93.	75.292		
Total	7050.105	94.			
Variable 3					
Between	317.019	1.	317.019	3.255	0.075
Within	9058.729	93.	97.406		
Total	9375.747	94.			
Variable 4					
Between	101.520	1.	101.520	1.373	0.244
Within	6878.838	93.	73.966		
Total	6980.358	94.			
Variable 5					
Between	1.350	1.	1.350	0.020	0.902
Within	6434.186	93.	69.185		
Total	6435.537	94.			