Coordinated and Aerobic Exercise do not Improve Attention in Graduate Students

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Abstract: Acute coordinative exercise, represented by various sports skills requiring bilateral use of hands or feet, has been shown to improve attention in school age children in a classroom setting. The purpose of this investigation was to determine if acute aerobic and coordinative exercise improves attention in graduate students in the same setting. Twenty-eight students (19 Women, 9 men; Age=24±1 years; BMI=22.9±0.6) enrolled in a graduate education program completed 3 sessions, each separated by 7 d. Immediately before a 1 h classroom lecture, subjects completed either 15 m of quiet sitting, aerobic exercise (walking), or coordinative exercise. Coordinative exercise consisted of a sequence of bilateral activities requiring gross and fine motor movement using balls of various sizes and types. Prior to and immediately after the lecture, subjects completed the d2 Test of attention. Subjects did not exercise or drink caffeine prior to participation. Heart rate was similar during aerobic and coordinative exercise. The total number of items processed (TN) and concentration performance (CP) increased from immediately post exercise to post-lecture in all conditions. The number of errors following coordinative exercise before the lecture was greater than the other conditions. The results of this investigation suggest that aerobic and coordinative exercise do not influence attention in graduate students.

Keywords: Aerobic, classroom processing, cognition, coordination.

INTRODUCTION

The effect of physical activity on cognitive function has generated strong interest recently. Acute bouts of aerobic exercise have been found to positively affect cognitive function in various age groups [1-3]. A review of studies done with adults provides strong support for the role of submaximal aerobic exercise of 60 min or less in facilitating aspects of information processing and cognitive function [4], while a meta-analysis of data from studies with school age children (4-18 years) suggests a positive relationship between physical activity and cognitive performance in a number of specific categories [5]. The exact mechanisms underlying the positive impact of acute exercise on cognitive function remain unclear; however, it has been hypothesized that they could be associated with changes in metabolism in the brain, increased cerebral blood flow, increased arousal, and improved relaxation [1].

In an academic setting the potential impact of acute exercise on attention is of particular interest. It is a commonly held belief that students do not pay attention during an entire classroom period and some authors suggest that an unmotivated student is unlikely to pay attention beyond 20 m [6]. Work by Bunce and colleagues [7] indicate that college-aged students experience ever-shortening cycles of engagement vs. non-engagement during a traditional 50 m lecture as well.

While most of the previous work examining the impact of exercise on cognitive function has focused on aerobic exercise, it is possible that other types of activities may be even more beneficial in an acute setting. Specifically, coordinative exercise, represented by various sports skills requiring bilateral use of hands or feet, may be particularly beneficial because of its ability to engage specific brain areas (cerebellum and frontal lobe) that have been associated with attention [8, 9]. This phenomenon has been demonstrated in adolescents by Budde and colleagues [10] who found that coordinative exercise had a more profound effect than traditional moderate exercise on attention using the d2 Test, a letter cancellation test measuring elements of sustained and selective attention. It is unclear if the positive impact of coordinative exercise extends beyond this age group. Consequently, the purpose of this investigation was to compare the effects of coordinative and aerobic exercise on attention in graduate students.
METHODS

Participants
Twenty-eight students (19 Women, 9 men; Age=24±1 years; BMI=22.9±0.6) enrolled in a Doctor of Physical Therapy Education program served as subjects in this investigation. Sixty four percent of subjects met or exceeded the American College of Sports Medicine’s recommendations for aerobic exercise [11]. Subjects completed 3 experimental sessions, each separated by 7d. Prior to the initiation of this study, each subject signed an informed consent approved by the Elon University Institutional Review Board for Protection of Human Subjects in Research. Subjects were asked to abstain from consuming caffeine and exercise for 5h prior to each experimental session.

Experimental Design
During this investigation, subjects completed each of three experimental conditions: rest (REST), aerobic exercise (AERO), or coordinated exercise (COORD). After each experimental condition, subjects participated in a 1h classroom lecture period. Attention of subjects was evaluated at two time points: 1) immediately after the exercise intervention and before the lecture (IPE) and 2) after the lecture (Post Lecture). All lectures revolved around the same general topic (research methods) and took place between 3 and 4 pm. Experimental conditions (REST, AERO, and COORD) were applied in a randomized counterbalanced fashion to control for any order effect and so that the specific lecture material and other academic expectations could be controlled.

Experimental Conditions
REST. During REST subjects completed a 15 m non-active control session where they sat quietly at their desks. They were not allowed to participate in any academic activity, to access any electronic devices, or communicate with others during this time.

AERO. During AERO subjects walked laps inside the academic building for 15 m. Subjects were encouraged to walk at a moderate pace (4 to 6 on the 10 point Borg RPE Scale) and not to talk to others during their AERO session. Subjects wore a Polar Heart Rate monitor during AERO and heart rate was recorded at 5, 10, and 15 minutes of AERO. For each subject, the three heart rate measures were averaged and so one heart rate measure is reported for each subject.

COORD. During COORD subjects completed a series of bilateral activities requiring gross and fine motor movement using balls of various sizes and types similar to those described by Budde and colleagues [10]. Subjects completed 5 different coordinated activities in a rotating station format. Subjects completed each station in groups of 6, spent 2 m at each station, and had 1 m to transition between each station. Activities at each station were: Station 1) subjects bounced volleyball with alternative hands while standing on a bench; Station 2) subjects bounced a volleyball and basketball simultaneously while standing; Station 3) subjects threw a tennis ball with alternating right and left hands into a basket at a distance of 10 meters. During this task subjects were provided a large number of tennis balls in an easily accessible basket so that subjects did not need to seek balls to complete the task; Station 4) two subjects faced each other at a distance of 5 meters and simultaneously passed a tennis ball (by alternative hands) and a soccer ball (by alternative feet) back and forth to each other; Station 5) subjects dribbled a basketball with their hands and a soccer ball with their feet while moving back and forth over a 30 meter tiled surface. Subjects wore a Polar Heart Rate monitor during COORD and heart rate was recorded at 5, 10, and 15 minutes of COORD. For each subject, the three heart rate measures were averaged and so one heart rate measure is reported for each subject.

Attention
Attention was assessed using the d2 Test for attention in a group, in a pencil and paper format [12]. All subjects completed the test simultaneously under the supervision of the same proctor. Subjects were given the test worksheet facing down on their desk. Prior to administration, the specific directions for the test were read to subjects and provided in a written form. After being provided test directions, subjects were instructed to turn over the work sheet and begin the test at the same time. During the test the subject scans a series of letters (d or p) that each have 1-4 dashes (2 above or 2 below) around each letter. Subjects are instructed to only cross out the letter “d” with two dashed lines. Worksheets have 14 lines each with 47 characters for a total of 658 items. Subjects view each line of text separately for 20 seconds. The d2 Test measures processing speed, rule compliance, and quality of performance. Performance on the test is determined by evaluating the total number (TN) of items processed, the number of mistakes or errors made during the test, and by calculating concentration performance (CP) [12]. TN accounts for all of the items processed, both relevant and irrelevant, and is representative of attention allocation, processing speed, amount of work completed, and motivation. The number or errors that occurred during the test includes errors of omission and commission. It is representative of the accuracy of work. CP is calculated by subtracting the number of errors of commission from the number of correctly crossed out items during the test. CP is an index of the integration of speed and accuracy during the test.

STATISTICAL ANALYSIS
Differences in measures of attention (TN, CP) between conditions and across time were analyzed using a Multiple Analysis of Variance (MANOVA). When differences between conditions or across time were observed, specific differences between conditions were evaluated using the Tukey post-hoc test. Differences in the heart rate response to AERO and COORD were assessed using a paired t-test. All data are presented as mean ± standard error (M±SE). Data were analyzed using the IBM Statistics package software version 21.0 (IBM Statistics, Armonk, NY, USA).
RESULTS
Heart rate was similar during AERO (121±3 bpm; 62% of predicted maximal heart rate) and COORD (125±4 bpm; 64% of predicted maximal heart rate) experimental sessions. These heart rate responses indicate that subjects exercised at a moderate intensity during AERO and COORD [11]. The total number (TN) [F(1,87)=108.07, p<0.001, η²=.554] of items processed and concentration performance (CP) [F(1,87)=104.07, p<0.001, η²=.545] increased from IPE to Post Lecture in all conditions (Figs. 1 and 2). There was no difference between conditions in either of these measures at any time point. An interaction between time and experimental condition was observed in the number of errors committed by subjects during the test [F(2,87)=3.54, p=0.033, η²=.075]. Post-hoc analysis revealed that the number of errors was higher before the lecture (IPE) during COORD compared to both REST and AERO (p=0.040) (Fig. 3). The number of errors after COORD (Post Lecture) was lower than before the lecture (p=0.035), but it was not different from the number of errors Post Lecture during REST and AERO.

DISCUSSION
It is generally accepted that students have difficulty maintaining attention in a traditional classroom setting. The purpose of this investigation was to determine if acute aerobic or coordinative exercise could be useful tools in assisting students to maintain attention in the classroom. Unfortunately, none of the components of the d2 Test used to evaluate attention in this investigation were influenced by aerobic or coordinative exercise.
The findings of this investigation differ from those
provided by Budde et al. in adolescents [10], Budde et al. in
adult students [13], Gallotta et al. in 8 to 11 yo [14], and
Palmer, Miller & Robinson in preschoolers [15]. Our
investigation is most comparable to that of Budde and
colleagues [10], in that we used the same tool to evaluate
attention (d2 Test) and we patterned our COORD
intervention after the one described by these authors. Budde
and colleagues [10] found COORD to improve attention with
better performance on the d2 Test following it than after a
resting control condition. It is possible that the differences in
response seen between these two investigations could be due
to the age and maturity of participants. It could also be
possible that the intensity of the intervention could have
influenced the different outcomes. This is unlikely because
the heart rate response to the activity was relatively higher in
this investigation (~64% of predicted maximal HR) than in
Budde et al. [10] (~59% of predicted maximal HR). Another
possibility is that the way subjects perceived the activity may
have influenced their attention. Perhaps the adolescents had a
more positive view of the activity than the graduate students
in this investigation. Neither investigation examined this
dimension so any discussion on this issue would be purely
speculative.

Very little information exists describing the impact of
moderate aerobic activity on attention as assessed by the d2
Test. Budde and colleagues [13] have examined the impact
of maximal aerobic exercise in adult students (ages 19-29)
on performance on the d2 Test and concluded that highly
physically active participants (> 3 times a week at the levels
recommended by the American College of Sports Medicine)
had a positive improvement in attention, while less active
participants (< 3 times a week) saw no benefit. This different
response to aerobic activity as compared to our investigation
could be easily explained by exercise intensity, suggesting
that a relatively high exercise intensity is needed for aerobic
exercise to have an impact on attention as measured via the
d2 Test.

Gallotta and colleagues [14] also describe an
improvement in performance in the d2 Test after physical
activity; however, the findings of this study are confounding
in that they also saw an improvement in attention after
classroom instruction. These authors argue that the stress or
stimulus of the activities is the underlying mechanism of
these improvements and the results are not due to a learning
effect. Examination of the data presented here and the data
presented by Budde et al. [10] and by Gallotta et al. [14]
suggest that performance on the d2 Test is significantly
impacted by repeated exposure. We attempted to control for
this by counterbalancing the conditions applied to subjects.
This approach may have been successful at controlling the
impact of an order effect on our findings; however, it may
have introduced so much error into the data that any
potential impact of the exercise interventions was not
apparent.

Palmer, Miller, and Robinson [15] found attention to be
improved in preschoolers after a planned 30 m movement
program as compared to a sedentary control condition. The
authors applied the Picture Depletion Task for Preschoolers
(DPTP) and found an approximately 42% reduction in the
number or errors of omission. In comparison, the
improvements described by authors using the d2 Test are at
best 15%. When considering the impact of the learning effect
on the d2 Test and the comparatively low magnitude of the
response in outcome measures, it seems reasonable to
conclude the d2 Test is probably not the best tool to evaluate
the impact of acute exercise interventions on attention. It
seems plausible that use of a computerized test with a greater
ability to precisely measure responses and the ability to
introduce more randomness in the test stimuli could have
yielded different results.

Fig. (3). Impact of aerobic (AERO) and coordinated exercise (COORD) on total errors (omission and commission) during the d2 Test.

*Indicates difference from Pre REST and Pre AERO (p<0.040).
# Indicated difference from Pre COORD (p<0.035).
In conclusion, we found no evidence to suggest that moderate aerobic or coordinative exercise has a beneficial effect on attention in graduate students. It is possible that these findings could have been influenced by exercise intensity or duration, and participants’ perceptions of the physical activity interventions. There also seems to be increasing evidence to suggest that the d2 Test may not be well suited to assess attention in an acute exercise environment.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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Declared none

REFERENCES