Original Research

Comparison of Affect and Cardiorespiratory Training Responses Between Structured Gym Activities and Traditional Aerobic Exercise in Children

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ABSTRACT

International Journal of Exercise Science 9(1): 16-25, 2016. Physical activities (PA) that are pleasurable are likely to be repeated. Structured gym activities (SGA) are defined as dodging, chasing, and fleeing games. Traditional aerobic exercises (TAE) are defined as treadmill, cycle ergometer, and elliptical exercise. The purpose of this investigation was to compare affect and cardiorespiratory training responses between SGA and TAE in children. Thirty-two participants (9.3±0.2) were randomized to either the SGA or TAE group. Exercise training was seven weeks, with two sessions per week, for 35 minutes per session. Affect was measured by the (+5 (pleasurable) to -5 (displeasurable)) feelings scale. Affect was recorded at the mid-point and end of each exercise session. The 20-meter pacer test was used to assess cardiorespiratory fitness at baseline and post intervention. Affect responses and heart rates were averaged across all exercise sessions. The SGA group scored 2.77±0.2 affect units higher than the TAE group ($p < 0.0001$). The TAE group significantly increased cardiorespiratory fitness (baseline 47.8±3.8; post 49.1±3.1 $ml \cdot kg^{-1} \cdot min^{-1}$; $p = 0.023$) with no change in the SGA group (baseline 46.3±3.5; post 47.2±2.7 $ml \cdot kg^{-1} \cdot min^{-1}$; $p = 0.127$). SGA reported more positive affect, suggesting they experienced greater pleasure during the exercise sessions than the TAE participants. SGA activities promote more positive affect, and therefore may increase children's PA participation.

KEY WORDS**:** Pleasure, displeasure, youth, physical activity

INTRODUCTION

Epidemiological trends show that children in the United States have decreasing levels of physical activity, while sedentary time has increased (22). Cross-sectional studies have determined that low cardiorespiratory fitness is a characteristic feature of overweight children (4, 20, 25). Additionally, cardiorespiratory fitness has emerged as an independent determinant of metabolic risk factors such as increased visceral and subcutaneous adiposity in children (13, 20, 24, 29). Pate and colleagues found that less than 3% of children met the Healthy People 2010 recommendations for vigorous exercise (23). Therefore, it is crucial that researchers find ways to enhance youth participation in physical activity. One strategy may be to identify developmentally appropriate physical activities that are pleasurable for children.

Many recent articles have called for reform in the field of pediatric exercise interventions (9, 11, 17, 28, 31). Children in exercise intervention studies have frequently been given the same exercise prescription as adults (8, 9, 11). Clinicians and researchers often prescribe traditional aerobic exercise (TAE) modalities (e.g. treadmill, cycle ergometer, and elliptical) where the intensity and duration can be monitored closely. Although this traditional style of aerobic exercise has been shown to be useful and effective in increasing cardiorespiratory fitness in adults and children, it may not be developmentally appropriate or realistic exercise programming for children (8, 19, 21). These TAE's limit free and open physical movement and may be perceived as 'boring' by the child, which may negatively affect compliance and adherence to the exercise program.

Developmentally appropriate exercise may be more pleasurable than non-developmentally appropriate exercise. Developmentally appropriateness is defined as matching the curricula to the level of children's emerging mental and physical abilities (3). Structured gym games are commonly used in elementary and middle school physical education classes and allow children to run freely throughout open space, use their imagination, and are not usually overly complex in skill and organization.

Evidence suggests that greater enjoyment (positive affect) experienced during exercise will lead to a greater enjoyment of the exercise session, promote a positive memory of the exercise experience and may play a role in predicting exercise adherence (5, 26). Affect refers to the intrapersonal or experiential core of all valenced (i.e. positive, negative / pleasant or unpleasant) responses including mood and emotions (5).

Even though adult programming for children is now recognized as inappropriate, there are still many unanswered questions regarding the best exercise approach with children (8). The purpose of this investigation was to compare the affect and cardiorespiratory training responses between structured gym activities (SGA) and TAE modalities in children. For the purpose of this investigation, SGA are defined as instructor organized dodging, chasing, fleeing games typically implemented in an open gymnasium. Although the games are structured, the child is free to move in open space at a self-selected intensity. TAE is defined as treadmill, cycle, and/or elliptical exercise modalities. We hypothesize that SGA would result in a more positive affective response as compared to TAE modalities. We also hypothesize that there will be no difference in cardiorespiratory training responses between the SGA and TAE in children when trained at a similar dosage. While others have used SGA in research and clinical interventions, this mode of exercise has not been directly compared to TAE modalities (7, 8, 19, 28, 32).

METHODS

Participants

Thirty-two healthy participants were recruited from a K-8 grade school in the Pittsburgh area. Participants were recruited from six different classrooms of 3rd, 4th, and 5th grade students. After voluntary recruitment, participants were screened for eligibility and informed consent from parents, and assent from child participants were obtained. The University of Pittsburgh's institutional review board approved this study. Eligible participants were randomly assigned to either the 'SGA' group or the 'TAE' group.

Subject date of birth, sex, height (cm), and weight (kg) were measured and recorded in the school's nurse office at baseline (one week prior to exercise training). Height and weight were measured on a standard weight beam physician scale with attached stadiometer with clothes and without shoes. Height and weight were used to calculate body mass index (BMI).

Protocol

Cardiorespiratory fitness was measured at baseline (one week prior to exercise training) and post-intervention (one week following completion of exercise training) using the 20-meter shuttle run, pacer test (15). The pacer test scores were calculated using the Leger et al. equation to determine $\dot{V}O_2peak$ ($mL \cdot kg^{-1} \cdot min^{-1}$) (14, 16). Affect was measured using the +5 to -5 Feelings scale developed and validated by Hardy and Rejeski (10). Ekkekakis and Petruzzello recommend the Feeling Scale be used to measure the valence component of affect related to exercise participation (6, 10, 26). The Feelings Scale is a valenced, 11-point scale that designates a measure +5 being pleasurable and very good and -5 being displeasureable and very bad. Participants were orientated to the scale at the beginning of each exercise session using a standardized script. While participants continued to exercise, or paused activity briefly, study personnel approached and presented the Feelings Scale to each participant and asked how the exercises made them "feel" at the midpoint and at the end of each exercise session. Study personnel recorded each subject's Feelings Scale rating.

Each subject was required to wear a Polar® chest strap heart rate monitor. While Participants continued to exercise or paused activity briefly, study personnel approached each participant and recorded heart rate at the midpoint and end of each exercise session. Participants were instructed to maintain an intensity of at least 60% of their age predicted maximal heart rate throughout the active period of the exercise session by self-monitoring their heart rate using a wrist-mounted display. Using a standard script, the research team verbally reminded participants throughout the exercise session of the minimum heart rate they should maintain while exercising. If a subject's heart rate was found to be below their age determined minimum, they were instructed and encouraged to increase their intensity.

Exercise training data (affect and heart rate) were collected for seven consecutive weeks during the fall semester of the 2010 school year. All data were collected during the participant's normal physical education class. Participants engaged in two exercise sessions per week for 35 minutes per session (14 exercise sessions total). All data collection procedures are described in figure 1. Participants in the SGA group were instructed to select a heart rate monitor as they entered the classroom and place the monitor on their chest in the locker room. Study personnel supplied participants with a watch and ensured the heart rate monitor was working properly. At this time, participants in the SGA group waited for instruction on the activity/game for the exercise session. Over the seven week exercise treatment, the SGA group participated in three different activities. Each activity was similar in nature and included modified and developmentally appropriate dodging, chasing, and fleeing components. All activities/games were modified to eliminate sitting or standing time, or 'time out.' For example, if a subject were 'tagged' they would be required to perform 20 jumping jacks before returning to full participation. When necessary, games were paused for instructional feedback or rule modification. Similar to the SGA group, participants in the TAE group were instructed to select a heart rate monitor as they entered the classroom, place the monitor on their chest in the locker room, and obtain a watch from study personnel. This group would then enter a separate room with one treadmill, two semi-recumbent bicycles ergometers, and three elliptical exercise machines. The TAE participants were not able to see the students in the gymnasium but the groups were able to interact before and after the exercise sessions. Participants were able to choose the exercise equipment they wished to use. At the halfway point of the exercise session participants were permitted to change exercise machines for the second half of the exercise session. Participants were permitted and encouraged to socially interact throughout the exercise session.

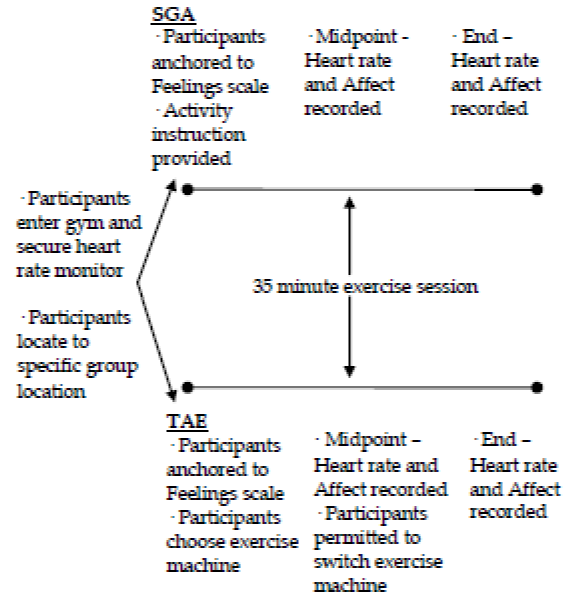

Figure 1. Data collection within exercise sessions.

Statistical Analysis

Group homogeneity and descriptive statistics were analyzed using chi-square and t-tests. Analysis of affect, cardiorespiratory fitness, and heart rate, were controlled for classroom, measurement time, age, sex, and BMI. Mean all-session affect was analyzed using an analysis of co-variance (ANCOVA). Though the affect distribution varied from normality, ANCOVA was chosen because it is a robust analysis for departures from normality. The exercise session mid-point and end Feelings Scale scores were averaged into one single-session score per group. A repeated measures test was used to analyze mean single-session changes in affect over the course of the 14 experimental sessions. Heart rate and changes in cardiorespiratory fitness values from baseline to follow-up were analyzed using t-tests. Effects were considered significant at the $p < 0.05$ level.

RESULTS

All participant characteristics are displayed in Table 1. The results of the chi square analysis and t-test indicate no differences in sex, age, BMI, or baseline cardiorespiratory fitness between groups. Participants were not overweight (based on the CDC growth chart for boys and girls aged 2-12 years(12)) and were relatively fit before the intervention.

Results from ANCOVA analysis show a statistically significant difference in affect scores between the SGA and TAE group. The all sessions average affect for participants in the SGA group was 2.77 affect units higher than participants in the TAE group (SGA: 4.63 ± 0.23; TAE: 1.86 ± 0.22; p<0.0001) (Figure 2).

Table 1. Mean baseline descriptive characteristics **(**reported as mean ± standard deviation *Predicted from shuttle run pacer test value) (14, 16)

	Structured Gym Activities	**Traditional Aerobic Exercise**	**p**
N	16	16	-
Sex (male)	7	9	p=0.999
Age (years)	9.4 ± 0.9	9.3 ± 1.0	p=0.789
BMI (kg/m^2)	18.3 ± 2.5	16.9 ± 1.6	p=0.069
*$\dot{V}O_2$peak ($mL \cdot kg^{-1} \cdot min^{-1}$)	46.3 ± 3.6	47.9 ± 3.8	p=0.248

When analyzed by group, ANCOVA analysis showed cardiorespiratory fitness significantly increased in the TAE group (baseline: 47.85 ± 3.83; post intervention: 49.16 ± 3.18 $mL \cdot kg^{-1} \cdot min^{-1}$, p=0.023), but not in the SGA group (baseline: 46.30 ± 3.56; post intervention: 47.21 ± 2.76 $mL \cdot kg^{-1} \cdot min^{-1}$, p=0.127) as displayed in Figure 4. Although the increase in fitness was observed in the TAE group and not the SGA group, there was no significant difference in the change scores between groups (TAE: Δ=1.31 ± 2.08 $mL \cdot kg^{-1} \cdot min^{-1}$; SGA: Δ=0.9 ± 2.23 $mL \cdot kg^{-1} \cdot min^{-1}$, p=0.355).

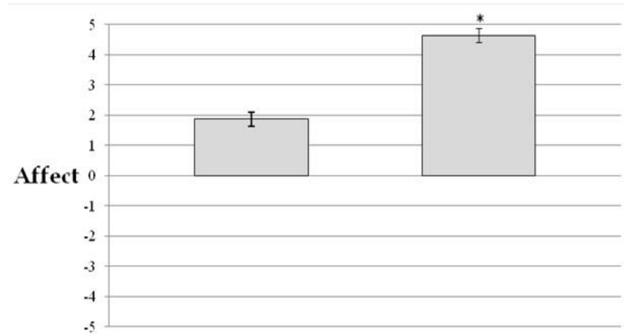

Figure 2. Difference in all sessions mean affect for traditional aerobic exercise and structured gym activities. * - Significant difference (p<0.0001) between groups. Bars represent standard error.

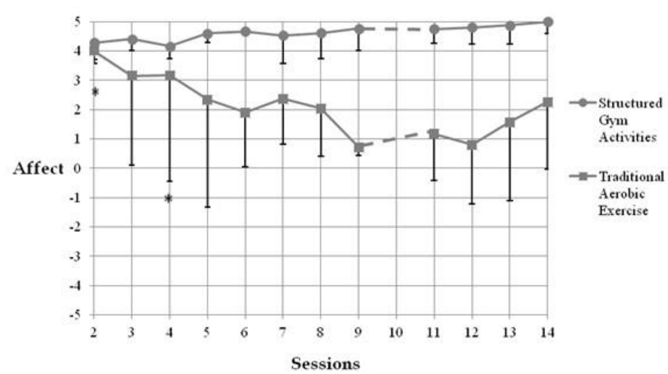

Figure 3. Difference in affect for traditional aerobic exercise and structured gym activities over time. * - Non-significant difference (p>0.05) between groups. Dashed line represents incomplete data from school holiday. Bars represent standard deviation.

Figure 3 shows the mean single session affect (midpoint and end session affect averaged) throughout the seven week (14 sessions) study period. Repeated measures analysis show the TAE group had statistically significant decreases in mean single-session affect responses as a function of time as the exercise stimulus proceeded. Affect was significantly higher in the SGA group at each exercise session except for sessions 2 and 4 where there was no statistical difference. Sessions 1 and 10 were excluded due to school holidays causing data to be incomplete.

Results from ANCOVA analysis show a statistically significant difference in unconsciously self-regulated exercise intensity between the SGA and TAE group. The all sessions average heart rate for participants in the SGA group was 23.2 bpm higher than participants in the TAE group (TAE: 147.18 ± 1.85 bpm; SGA: 170.33 ± 2.58 bpm, $p<0.0001$) (Figure 5).

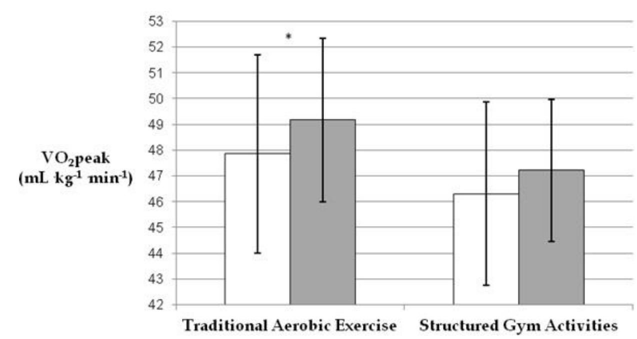

Figure 4. Changes in estimated VO_2peak by group from baseline to post intervention. White column represents baseline. Gray column represents post intervention. * - Significant difference ($p=0.023$) within group. Bars represent standard deviation. VO_2peak in mL·kg^{-1}·min^{-1} derived from 20-meter pacer run prediction equation.

DISCUSSION

A primary aim of this investigation was to compare affect between SGA and TAE in children. A secondary aim was to compare cardiorespiratory training responses between SGA and TAE in children.

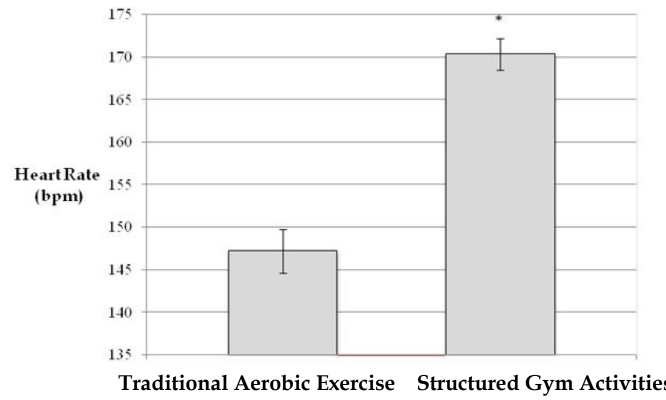

Figure 5. Difference in self-regulated exercise heart rate between groups. * - Significant difference ($p<0.0001$) between groups. Bars represent standard error.

The results of this study suggest that children participating in SGA have a more positive affect toward the exercise than children participating in TAE. This may be due to the nature of the SGA used presently. The dodging, chasing, fleeing activities within the SGA group were developmentally appropriate; participants had the freedom to move in open space, and the ability to compete/interact with peers. In a review of qualitative studies, Allender and colleagues observed that fun, enjoyment, and social support were stronger motivators to participate in physical activity than perceived health benefits in both children and adults (1). Furthermore, children see enjoyment and social interaction with peers as reasons to be physically active (1). Although the participants in the TAE group exercised together and interacted socially with one another, the modalities were very individual in nature, highly structured, and did not allow participants to freely communicate and work together to accomplish a task. Highly structured and individualized tasks may be perceived as less enjoyable for children and may be less preferred to more social and creative tasks. Additionally, it was observed that affect responses in the TAE group were similar to SGA at the beginning of the data collection period but decreased (became less positive) as the study progressed. This affect response is likely due to novelty with the exercise machines early in the study, which decreased over time possibly leading to boredom. Qualitative studies have found that unusual physical activities are a motivating factor for children, while highly structured activities are a barrier to physical activity (1). This was the first time for many of the participants to use an elliptical, treadmill, or cycle ergometer. The use of these exercise modalities may have resulted in enjoyment early in the study. However, participants may have felt restricted given the specific guidelines on the intensity and duration of the exercise. As the participants became more familiar with the exercise equipment, it is possible novelty decreased which may have lead to less positive affect. Future studies should further examine this relationship and explore child affect, exercise preference, and changes in cardiorespiratory fitness using mixed exercise modalities (SGA and TAE) over time.

Cardiorespiratory fitness increased significantly ($p=0.023$) in the TAE group, while no increase was observed in the SGA group. The SGA used were largely anaerobic in nature, involving short bursts of high-intensity exercise, followed by periods of low-intensity movement (30). Furthermore, the SGA may have had less on-task-time due to necessary instructional time (e.g., explaining game rules, stopping activity for game modification, classroom feedback). However, on-task-time was not foreseen as a significant confounding variable and was not measured. Future investigation should include a measure of time the participants are actively participating in moderate to vigorous physical activity. Conversely, participants in the TAE group had sustained activity throughout the entire exercise session (based on subject observation) and, as a result, this may have resulted in a greater adaptation in the aerobic energy system. Although some differences were observed, it should be noted that $\dot{V}O_2$peak increased in the TAE group by 1.3 $mL \cdot kg^{-1} \cdot min^{-1}$ while $\dot{V}O_2$peak increased in the SGA group by 0.9 $mL \cdot kg^{-1} \cdot min^{-1}$. The difference in change between groups was non-significant ($\Delta=0.4$ $mL \cdot kg^{-1} \cdot min^{-1}$; $p=0.355$). The clinical and practical significance of a 0.4 $mL \cdot kg^{-1} \cdot min^{-1}$ difference in $\dot{V}O_2$peak may be trivial in some research and intervention settings.

Participants in the SGA group unconsciously self-regulated exercise at a higher intensity. These results are supported by Macfarlane and Kwong who found that children participating in ball games and free play lessons had significantly higher heart rates than children participating in gymnastic lessons (18). Heart rate alone may not accurately reflect the physiological stress associated with exercise, as it may be effected by sympathetic nervous system response associated with the dodging/chasing/fleeing games and free play (18). Additionally, participants in the TAE group were continuously active throughout the session while maintaining a steady state heart rate which may have had a beneficial effect of cardiorespiratory fitness adaptation.

Interestingly, participants in the SGA group exercised at a higher heart rate while also reporting more positive affect. This observation is contrary to previous investigations using TAE modalities which demonstrated a pattern of affect decreasing as exercise intensity increased (2, 27). The present findings suggest that the SGA group may have placed less of an attentional focus on their introspective pain cues associated with exercise at a high intensity and greater attention on the activity itself, the impact of environmental factors such as gym game equipment, the opportunity to move throughout a large open space, leading to a higher unconsciously self-regulated exercise intensity while maintaining high affect.

There are several limitations with this study that should be noted. Participants were not prescreened for physical activity participation before entering the study and were not restricted to refrain from physical activity participation outside of the study environment. Also, heart rate was measured only during the active time of the session (midpoint and end of activity), not accounting the inactivity time used for instruction in the SGA group. Accounting for inactivity heart rates may have affected the average heart rate results between groups and may explain the differences in cardiorespiratory fitness. On-task-time between groups was not measured and recognized as a limitation to the interpretation of study results. Participants in the SGA group participated in three different gym activities, while participants in the TAE group could choose from three different exercise machines. Although it was not recorded, success or enjoyment in one game or machine vs another may have affected heart rate and/or affect score. Lastly, the gym activities were mostly anaerobic in nature which may have had an effect on the cardiorespiratory fitness adaptations in the SGA group.

Although TAE has been shown to be useful and effective in increasing cardiorespiratory fitness in children, it may not be developmentally appropriate, enjoyable, or realistic exercise programming (8, 19, 21). This study demonstrates that SGA elicit a more positive affect response compared to TAE in children, while TAE was more effective on increasing cardiorespiratory fitness. While children participating in SGA may unconsciously self-regulate exercise at a higher intensity, the anaerobic nature of the structured gym games resulted in less of an aerobic training benefit. Although adult programming for children is now recognized as inappropriate, there are still many unanswered questions regarding the best exercise approach with children (8). More research is needed to determine what dosage (on-task-time and intensity) of SGA is required to elicit a cardiorespiratory training stimulus comparable to TAE while maintaining a positive affect. Many of the SGA used presently may be modified to become less anaerobic, and more aerobic in nature. Future studies should directly compare aerobic SGA with aerobic TAE and anaerobic SGA with anaerobic TAE to determine developmentally appropriate and enjoyable physical activities for youth that elicit an adequate training stimulus. It is recommended to control for unconsciously self-regulated exercise intensity to determine if the high exercise intensity leads to high affect scores in youth, or if it is the nature of the physical activity modality. Also, subsequent investigations should evaluate the impact of obesity, gender, and developmental stage on the affect response to structured and unstructured gym activities. With obesity and prevalence of sedentary behavior in youth continuing to rise, additional research on effective exercise treatment is valuable. Valid and enjoyable physical activities for youth that elicit an appropriate cardiorespiratory training response may assist in the future development effective treatment programs for youth.

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