Acute aerobic exercise enhances students' creativity

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Running head

Aerobic exercise and creativity

Abstract

The purpose of this study was to evaluate the effectiveness of an aerobics games class on creativity in children during the school day. Participants were 96 students (age = 9.84 ± 1.12 years), 48 girls and 48 boys. The students were randomly assigned to the experimental group (EG, n = 48) or the control group (CG, n = 48). The PIC-N test was employed to analyse narrative and graphic creativity. The EG took part in an aerobic games session lasting 45 minutes, whilst the CG did not take part in a physical education class on that school day. As for group x time interaction, the EG experienced significant improvements in all creativity variables except in graphic originality, graphic titles, and graphic details. However, the CG did not improve any creativity variables. The findings suggest that acute aerobic exercise enhances students' creativity, which could be important for academic achievement.

Key words: divergent thinking, physical education class, children

Introduction

The importance of physical activity for health is well known and research has noted both physical and psychological benefits when children participate in physical activities (Ahn & Fedewa, 2011**;** Janssen & Leblanc, 2010). In recent years, there has been a growing interest due to the benefits of physical activities for academic and cognitive performances and executive functions (EFs) (Ellemberg & St-Louis-Deschênes, 2010; Gallotta et al., 2014; Janssen et al., 2014; Soga, Shishido, & Nagatomi, 2015). Specifically, cardiorespiratory fitness and motor skills play an important role in cognitive development during childhood and young adulthood (Aberg et al., 2009; Haapala et al., 2013). Aerobic exercises have the potential to promote multiple facets of development through their direct impact on EFs (Best, 2010). In addition, both acute and chronic exercise may facilitate EFs (Best, 2010).

Chang, Labban, Gapin, and Etnier (2012) and Gallotta et al. (2014) showed that exercise duration, exercise intensity, participant fitness and specific types of physical exercises performed during physical activity interventions were significant moderators in the association between physical activity and cognitive performance. Several previous studies showed a relationship between acute exercise and cognition in children (Best, 2010; Budde, Voelcker-Rehage, Pietraßyk-Kendziorra, Ribeiro, & Tidow, 2008; Chang et al., 2011; Hillman, Snook, & Jerome, 2003; M. B. Pontifex, Hillman, Fernhall, Thompson, & Valentini, 2009). Pesce, Crova, Cereatti, Casella, and Bellucci (2009) indicated that an acute bout of aerobic exercise, as performed by students during physical education classes, may facilitate memory storage. Likewise, Pontifex, Hillman, Fernhall, Thompson, and Valentini (2009) concluded that an acute bout of aerobic exercise may facilitate working

memory. Recently, Dunsky et al., (2017) showed an acute effect of both resistance training vs. an aerobic single session on attention and executive functioning in adults.

Measures of physical activity and aerobic fitness have been associated with childhood neurocognition, but their contributions to cognitive health through development are still poorly understood (Chaddock, Pontifex, Hillman, & Kramer, 2011). Further research is necessary to gain insight into the relationship between physical activity and cognition, particularly for creativity, about which there has been little research (Latorre Román, García Pinillos, Pantoja Vallejo, & Berrios Aguayo, 2017; Blanchette et al., 2005; Campion & Levita, 2014; Hinkle, Tuckman, & Sampson, 1993; Ramocki, 2002; Steinberg et al., 1997).

Blanchette, Ramocki, O'del, & Casey, (2005) showed an association between aerobic exercise and creative potential; likewise Steinberg et al. (1997) demonstrated an increase in flexibility after 25 minutes of aerobic exercise relative to a television watching activity for a similar period with the same participants. In addition, Scibinetti & Tocci (2011) demonstrated a significant association between creative moving and creative thinking (fluency, flexibility) except for originality Recently, Leso, Dias, Ferreira, Gama, & Couceiro (2017).showed that there is a strong correlation between creativity and game intelligence for the soccer players. Therefore, some studies have shown that physical exercise may sometimes enhance creativity, but currently few reports are available about that, and the evidence is still inconclusive (Colzato, Szapora, Pannekoek, & Hommel, 2013).

Taking into account the information given above, the aim of this study was to evaluate the acute effects of an aerobics games class on creativity in elementary school-aged

children during the school day. The hypothesis was that creativity might be influenced by aerobics exercises and might already be visible after acute bouts of exercise.

Method

Participants

The participants comprised 96 children (age = 9.84 ± 1.12 years, age range = 8–12 years), 48 girls and 48 boys, belonging to a primary school in southern Spain; the sample is therefore one of convenience. The students were randomly assigned to the experimental group (EG, n = 48) or the control group (CG, n = 48). A verbal description of the nature and purpose of the study was given to their parents and school supervisors. Parental consent was obtained for the participants. Students with intellectual or physical disabilities were not involved in this study. The study was conducted in adherence to the standards of the Declaration of Helsinki (2013 version) and following the European Community's guidelines on *Good Clinical Practice* (111/3976/88 of July 1990), as well as the Spanish legal framework for clinical research on humans (Real Decreto 561/1993 on clinical trials). The informed consent and the study were approved by the Bioethics Committee from the University of Jaen.

Instruments and testing

Creativity was measured using the PIC-N test (González & Mairal, 2004), which was partly inspired by the classic studies of Guilford and Torrance. The PIC-N, which has been shown to have good psychometric properties (Cronbach's alpha = .83, and convergent validity with G factor, $r = .40$, $p < 0.01$), was specifically designed for the Spanish population (8–12 years) and is widely used for the assessment of creativity (Ferrándiz,

Ferrando, Soto, Sáinz, & Prieto, 2017; González & Mairal, 2004; Soto, Ferrando, Sáinz, Almeida, & Prieto, 2015). It evaluates creativity by examining how subjects use their imagination in four different tasks; the first three tasks or games focus on narrative creativity whilst the fourth task gauges graphical creativity. In game 1, the instructions were: "Look at the picture and imagine everything that could be happening. Don't tell a story, but write all the ideas that come to your mind (each one on a different line). In this game there are no right or wrong answers, so let go your imagination and fancy and try to write as many ideas as you can." In game 2, the instructions were: "Write a list of everything that you could do with a plastic pipe. Think of interesting and original things, however fantastic they may be. You can use the number and length of pipes you wish." In game 3, the instructions were: "Imagine what would happen if suddenly every squirrel became a dinosaur. Don't tell a story, but write a list of the things that could happen." Finally, in game 4, the instructions were: "On this page you will see some incomplete drawings. Try to complete them with such originality that no one else would draw the same. When you have finished, write an interesting title for each drawing." Indicators of fluency, flexibility, originality, elaboration, shadows and colour, title, and special details were recorded.

For the assessment of perceived exertion (RPE) after the completion of the aerobic games session the Borg Scale (Borg, 1982) was used for scoring items from 0 to 10 (low intensity to high intensity).

Procedure

In three separate sessions, a team of previously trained researchers performed the evaluation. The PIC-N test was administered during two testing sessions and answers were

scored individually. The examiner gave the children the exercise sheet and a separate sheet for answers. The requirements for passing the test were explained to the students and they were given a maximum of 40 minutes to complete it. The examiner remained in the classroom whilst the children were completing the test and was available to answer questions. The children were required to remain silent and show intense concentration in order to enhance their creativity. A week later, the participants were newly assessed. The students took the PIC-N test in the last class of the school day, the EG having previously performed aerobic games lasting 45 minutes in a PE class (20 minutes after the end of the PE class, the PIC-N test was performed in the classroom), while the CG did not take part in a PE class on that school day and remained sitting in the classroom working on other school subjects (e.g. mathematics and language). The intensity of the aerobic games was monitored through the RPE. In this study, aerobic games such as those employed by Pesce et al. (2009) were used (chase games, team games, small-sided games), which require cooperation with other children, strategic behaviour, coordination and adaptation to continually changing task demands. Aerobic games also require skilled and complex movement, which directly relies on the prefrontal neural circuitry supporting EFs; however, repetitive aerobic exercises (aerobic circuit training) probably requires less cognitive engagement (Best, 2010). Verbal encouragement ensured maximal effort throughout all the games.

Results

The internal consistency of the PIC-N was assessed by calculating the Cronbach's alpha coefficient obtaining α=.80. Moreover, a 2x2 analysis of variance (ANOVA) with repeated measures (group x measurement) was conducted for the dependent variables.

Differences between groups and sociodemographic characteristics

No significant differences, in a preliminary analysis through an independent *t* and chi-squared test, were found between the EG and CG, either in age (9.75 ± 1.12 years vs. 9.94 ± 1.13, respectively, p = 0.418), sex distribution (EG = 54.2% girls vs. CG = 47.9%, p = 0.540), parents' socio-economic status (EG = 87.5% medium level vs. CG = 93.8% medium level, p = 0.499) or parents' academic level (EG = 37.5% university studies vs. CG = 25.0% university studies, p = 0.314). In the EG, RPE = 5.46 ± 2.85 was found. In addition, tests of normal distribution and homogeneity (Kolmogorov-Smirnov and Levene's, respectively) were conducted on all data before analysis.

Influence between groups of an aerobic game class in creativity

Table 1 shows performance in the PIC-N test for both the EG and the CG in both conditions (pretest/post-test). In the pretest, there were no significant differences in any variable. However, in post-test conditions, the EG displayed higher scores than the CG in all creativity variables except in narrative originality, graphic titles and graphic details, for which no significant differences were found. As for group x time interaction (within-group), the EG experienced significant improvements in all creativity variables except in graphic originality, graphic titles and graphic details. However, the CG did not improve in any creativity variables; indeed, the CG displayed a worsening in total graphic creativity. Additionally, effect sizes for group differences were expressed as Cohen's *d* (Cohen, 1988);

effect sizes of less than 0.4 represented a small difference, whereas effect sizes of 0.41–0.7 and greater than 0.7 represented moderate and large differences, respectively (Thomas, Silverman, & Nelson, 2015).

Discussion

The aim of this study was to evaluate the acute effects of an aerobics games class on creativity in elementary school-aged children during the school day. According to the Borg Scale (Borg, 1982), the intensity of this PE session was moderate. The main finding was that creativity might be influenced by aerobic exercises and might already be visible after acute bouts of exercise. In this regard, the results provide some preliminary evidence of a link between physical exercise and creativity, but as Colzato et al. (2013) indicated, the nature and the consequences of this link depend on the particular task and the fitness of the individual.

These results are in line with those of previous studies (Blanchette et al., 2005; Colzato et al., 2013; Steinberg et al., 1997). In addition, Blanchette et al. (2005) showed that the creative potential will not be significantly different immediately following exercise to that after a 2 hour lag time following exercise (enduring residual effects). Other studies have shown that acute exercise improves certain aspects of cognitive processing. Hillman, Buck, Themanson, Pontifex, & Castelli (2009) showed that single bouts of moderately intense aerobic exercise (i.e. walking) may improve the cognitive control of attention in preadolescent children. Pontifex et al. (2013) demonstrated greater performance in the areas of reading and arithmetic following a single 20-minute bout of exercise in children between the ages of 8 and 10. Moreover, in a similar study, P. Latorre Román et al., (n.d.) showed

that the execution of moderate aerobic exercise with cognitive engagement causes better selective attention in elementary school-aged children during the school day.

The basis for this theory is the fact that aerobic exercise produces not only general but also specific physiological changes in the brain, besides causing an immediate neurochemical response that may enhance cognitive performance (Best, 2010). Moreover, exercise has been shown to positively affect cognitive performance, due to the neuronal connection between the cerebellum and the frontal cortex (Budde et al., 2008).

Conversely, the CG did not improve in any creativity variables; indeed, the CG displayed a worsening in total graphic creativity. One possible explanation for this might be that long sedentary periods in school affect the cognitive processes such as creativity. In this regard, Mahar et al. (2006) indicated that long periods of instructional time without a break might be counterproductive in terms of academic performance. Some previous papers (Jarrett & Maxwell, 1998; Pellegrini, Huberty, & Jones, 1995) pointed out that elementary school-aged children who undergo prolonged periods of academic instruction often become more fidgety or restless and experience reduced concentration and attention.

According to previous studies (Bolandifar & Noordin, 2013; Naderi, Abdullah, Aizan, Sharir, & Kumar, 2010), creativity is associated with academic performance, and therefore, taking into account the findings of the current study, it is important to promote legislative changes to increase physical activity opportunities for school-aged children that will benefit not only physical health, but also cognitive development and academic achievement. The pre-pubertal period offers many opportunities to stimulate cognitive function. However, the relationship between participation in physical sports activity and cognitive performance has been a subject of discussion between advocates and sceptics of physical activity, as well as

parents concerned about decreases in study and homework time. Additionally, opportunities to be physically active at school are limited because of pressure to perform well academically (Mahar et al., 2006). However, participation in physical activity is not associated with less time dedicated to study (Ruiz et al., 2010). Accordingly, Lupu (2012) recommended that physical education should be taught from preschool, since children who constantly participate in physical education lessons have a more developed creative capacity.

This current study had several limitations that will motivate future work. One of those limitations is that the physical fitness and physical activity levels of the participants were not controlled. Also, academic differences between groups were not recorded. In this regard, the type of physical activity, its intensity and the length of the activity may have an influence on the acute effect of a physical activity bout on cognition (Mirka Janssen, Toussaint, van Mechelen, & Verhagen, 2014). Therefore, different forms of physical activity need to be compared to test whether these have important effects on creativity. More experimental studies with a comparable methodology, especially in the school setting, are needed to strengthen this evidence (Janssen et al., 2014). However, to the best of our knowledge, little is known about the relationship between creativity and physical activity in children, therefore strength of this study is to be a pioneer in this matter.
In conclusion, the findings suggest that acute aerobic exercise enhances student' creativity, which could be important for academic achievement.

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Table 1

Results of creativity (pretest-post-test) in experimental group and control group

Variables	Group	Pretest Mean (SD)	Post-test Mean (SD)	P-value (group x time)	**Cohen's d**
Narrative fluency	CG	9.34 (3.06)	9.72 (3.14)	0.350	-0.123
	EG	9.87 (4.24)	13.15 (4.45)	<0.001	-0.762
p-value (time x group)		0.488	<0.001		
Narrative flexibility	CG	6.91 (1.89)	6.96 (2.36)	0.908	-0.023
	EG	7.17 (2.33)	9.04 (3.09)	<0.001	-0.690
p-value (time x group)		0.562	<0.001		
Narrative originality	CG	2.64 (2.07)	3.30 (2.28)	0.145	-0.306
	EG	3.17 (2.59)	4.30 (2.82)	0.014	-0.468
p-value (time x group)		0.276	0.062		
Total narrative creativity	CG	18.83 (5.36)	19.96 (6.60)	0.196	-0.189
	EG	20.23 (7.28)	26.62 (9.09)	<0.001	-0.784
p-value (time x group)		0.290	<0.001		
Graphic originality	CG	9.34 (2.36)	8.40 (2.30)	0.010	0.407
	EG	10.19 (2.23)	10.68 (2.04)	0.170	-0.231
p-value (time x group)		0.076	<0.001		
Graphic design	CG	1.85 (1.88)	2.09 (1.36)	0.348	-0.147
	EG	2.02 (1.43)	2.62 (1.19)	0.018	-0.460
p-value (time x group)		0.624	0.047		
Graphic shadow and colour	CG	0.47 (0.88)	0.34 (0.93)	0.445	0.145
	EG	0.34 (0.63)	0.87 (0.96)	0.002	-0.659
p-value (time x group)		0.422	0.008		
Graphic title	CG	1.34 (1.43)	0.91 (1.23)	0.102	0.325
	EG	1.43 (1.67)	1.43(1.37)	1.000	0.000
p-value (time x group)		0.792	0.061		
Graphic details	CG	0.72 (1.03)	0.57 (0.95)	0.335	0.152
	EG	0.70 (0.72)	0.85 (0.93)	0.335	-0.182
p-value (time x group)		0.908	0.158		
Total graphic creativity	CG	13.74 (4.99)	12.28 (4.60)	0.050	0.307
	EG	14.68 (4.52)	16.43 (4.16)	0.020	-0.407
p-value (time x group)		0.343	<0.001		
Total creativity	CG	32.57 (7.01)	32.26 (9.38)	0.771	0.037
	EG	34.91 (9.59)	42.98 (12.14)	<0.001	-0.750
p-value (time x group)		0.182	<0.001		

Note: SD = standard deviation, CG = control group, EG = experimental group