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BIKE DESK AN INTERVENTION PROPOSAL TO IMPROVE THE LEVEL OF PHYSICAL ACTIVITY AND COGNITIVE PERFORMANCE IN PRIMARY SCHOOL CHILDREN

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Abstract. The aim of this study was to analyze the effect of 5 weeks of interactive pedaling during classes on physical fitness, school skills and creativity in primary school children. A total of 89 children (age range = 10-12 years) participated in this study, although due to the COVID-19 pandemic only 37 students could be considered for the analysis of the results. The students were randomly assigned to two groups, experimental group (EG) and control group (CG). The GE performed a moderate to vigorous intensity cycling program with cognitive engagement for 5 weeks, 4 days a week. Physical fitness, school skills and creativity were assessed. No significant differences were found between groups in terms of creativity. The CG experienced significant improvements in numeracy and total ASD. In addition, both groups showed significant improvements in the horizontal jump test. In conclusion, the implementation of pedal machines does not interfere with the academic performance of schoolchildren and can therefore be an effective means of improving students' physical activity levels.

Keywords: Interactive pedaling, physical fitness, school skills, creativity.

BIKE DESK UNA PROPUESTA DE INTERVENCIÓN PARA MEJORAR EL NIVEL DE ACTIVIDAD FÍSICA Y EL RENDIMIENTO COGNITIVO EN ESCOLARES DE EDUCACIÓN PRIMARIA

Resumen. El objetivo de este estudio fue analizar el efecto de 5 semanas de pedaleo interactivo durante las clases en la condición física, aptitudes escolares y creatividad en niños de Educación Primaria. Un total de 89 niños (rango de edad = 10-12 años) participaron en este estudio, aunque debido a la pandemia del COVID-19 solo 37 alumnos se pudieron considerar para el análisis de los resultados. Los estudiantes fueron asignados al azar a dos grupos, grupo experimental (GE) y grupo de control (GC). El GE realizó un programa de pedaleo de intensidad moderada a vigorosa con compromiso cognitivo durante 5 semanas, 4 días a la semana. Se evaluaron la aptitud física, las aptitudes escolares y la creatividad. No se encontraron diferencias significativas entre los grupos en cuanto a creatividad se refiere. El GC experimentó mejoras significativas en el cálculo y el total TEA. Además, ambos grupos mostraron mejoras significativas en el test del salto horizontal. En conclusión, la implementación de pedaleadores no interfiere con el rendimiento académico de los escolares por lo que puede ser un medio efectivo para la mejora de los niveles de actividad física del alumnado.

Palabras clave: Pedaleo interactivo, condición física, aptitudes escolares, creatividad.

Introduction

It is well known that, in the 21st century, childhood obesity remains one of the most important public health problems in the world(Yi et al., 2019). This problem is worldwide and affects many countries. Obese and overweight children are likely to become obese adults, leading to a greater tendency to suffer from diseases common in adults such as diabetes, arterial hypertension and cardiovascular diseases at younger ages, as well as various types of cancer (Muñoz and Arango, 2017). Consequently, it is essential to prioritize the prevention of childhood obesity because this global problem is generally preventable.

People who spend more time in physical activity (PA) show lower risks of developing metabolic syndrome, cardiovascular disease, diabetes, cancer, hypertension, obesity and mental health problems such as anxiety and depression (Belmonte Darraz et al., 2021; Esteban-Cornejo et al., 2015; Parvin et al., 2020; Wu et al., 2022). The benefits of physical activity are multiple, being its main objective the improvement of physical condition in different populations (Cobo-Cuenca et al., 2019; Huang et al., 2019; Kritsilis et al., 2018; Ruiz et al., 2006) but in addition, evidence from the last decades has shown the influence of regular physical activity in improving the quality of life (Arbinaga et al., 2011; Ruiz et al., 2016), improvement in cognitive processes (Bahdur et al., 2019; Kvalø et al., 2019; Latorre-Román et al., 2020; Van Der Niet et al., 2016), improving social and personal relationships, (Alves Donato et al., 2021; Gentile et al., 2011) and as a preventive mechanism for degenerative diseases (Buchman et al., 2020; Ma et al., 2022; Soulard et al., 2021).

This is why the World Health Organization (WHO) recommends that children and young people between the ages of 5 and 17 years should engage in at least 60 minutes a day of moderate to vigorous physical activity, with the aim of improving cardiorespiratory, muscular and bone health functions (WHO, 2021, para. 2-3). In Spain, physical education classes are taught only 2 hours a week, which makes it difficult for students to comply with these recommendations the rest of the week.

Several studies demonstrate the positive acute effects of exercise on several executive functions (EF) and cognitive variables in primary school students, such as inhibitory control, creativity, change, attention and memory (Berrios Aguayo et al., 2018, 2019; Latorre Román et al., 2018; Peruyero et al., 2017; Tsukamoto et al., 2016). In addition, previous studies have shown benefits in cognition after different school PA programs (Fisher et al., 2011; Lind et al., 2018). In addition, as people age, the deterioration of functional reserve (cognitive-motor) accelerates, increasing motor variability throughout old age, and PA through dual tasks is a predictor of health to prevent the prevalence of falls in older populations (Grobe et al., 2017; Wollesen et al., 2017).

In this sense, dual tasks represent a great opportunity to improve the cognitive and attentional capacity of schoolchildren, since a dual task refers to the ability of a person to perform two tasks (motor-cognitive) simultaneously (Plummer et al., 2011). The positive benefits of dual tasks focus on the ability of students to maintain attention in the face of internal or external stimuli that are presented in the learning process (Theill et al., 2013).

Some previous studies employed non-validated methods to analyze the link between PA and student cognition levels, relying on short-term, non-randomized, small-sample trials (Donelly et al., 2016).

Therefore, to date, there is no evidence of beneficial effects of PA interventions on cognitive learning. To that effect, the assumption that PA will have benefits in the school learning environment has not yet been validated (Donelly et al., 2016).

Most schoolchildren in Spain sit for an average of 20 hours per week. Researchers looking at the Primary Education workplace and environment with active workstations to combat sedentary behavior have shown improved cognition without distraction (Ojo et al., 2018).

Taking into account the above information, the main objective of this research was to analyze the effect of 5 weeks of interactive pedaling during classes on physical fitness, school skills and creativity in primary school children. We hypothesized that those children exposed to this training program would improve both the physical and cognitive abilities analyzed.

Method

The study involved 89 schoolchildren, 51 girls and 38 boys. The children were selected from a school in the province of Córdoba. The structuring of the groups, both control (CG) and experimental group (EG), was done in a rounded manner. Inclusion criteria were established as not suffering from physical, mental or intellectual disease or disorders. The parents and/or legal guardians of the child had to give consent to participate and the study complied with the ethical criteria of the Helsinki declaration (2013). Due to the COVID-19 pandemic situation, finally only 37 children could be considered for data analysis, 19 in the CG and 18 in the GE.

Parents completed a sociodemographic questionnaire with information on marital status, educational levels and socioeconomic status. Height (cm) was measured with a stadiometer (Seca 222, Hamburg, Germany) and weight with a balance (Seca 899, Hamburg, Germany). Body mass index (BMI) was calculated by dividing weight (in kilograms) by height squared (in meters).

Physical Condition: For aerobic capacity, the Léger test was performed (Léger et al., 1988)which consisted of a 20 m multi-stage out-and-back run with increasing speed in each run, indicating the pace with audible signals; the best result corresponds to the highest number of stages completed. In addition, to measure the explosive strength of the lower body, the horizontal jump test was used (J. R. Ruiz et al., 2011)which consists of a two-legged horizontal jump in which the help of the arm action can be used. The best score was the distance achieved (between take-off and the heel of the nearest foot on landing), a shorter distance indicating poor performance. The test was performed twice and the best score was recorded in centimeters.

Cognitive tests: School skills were assessed by the School Aptitude Test (TEA) (Ruiz Alva, 2014). This test evaluates intelligence from the classical approach that understands it as the subject's aptitude to learn. It is divided into 3 levels on homework performance. Each level explores 3 fundamental school skills: verbal, numerical and reasoning.

Verbal ability is assessed by means of images (verbal identification of the image), different words (verbal reasoning) and vocabulary (verbal comprehension); the sum of these parts comprises the total verbal aptitude (maximum and minimum values = 0-50). On the other hand, the sum of reasoning (maximum and minimum values = 0-27) and numerical skills (maximum and minimum values = 0-55) is the total of nonverbal skills (maximum and minimum values = 0-42).

Finally, the sum of verbal and nonverbal skills is the total score that measures actual school aptitude (maximum and minimum values = 0-132). In order to evaluate any aptitude, there is a maximum time to perform. When time ran out, the children had to stop writing. As for internal consistency reliability, this test yielded a Cronbach's alpha = 0.86 for the verbal component; Cronbach's alpha = 0.82 for numerical; Cronbach's alpha = 0.93 for reasoning and Cronbach's alpha = 0.92 for total score (Ruiz Alva, 2014).

The Torrance Thinking of Creative Test (TTCT Torrance Thinking of Creative Test) was used to assess creative ability. The test was developed by Torrance and his collaborators in 1966. It has subsequently been revised at different times, 1974, 1984, 1990 and 1998. It consists of two independent tests, the TTCT-Verbal and the TTCT-Figurative, each of them with two parallel forms, A and B. In our work we have used the TTCT-Figurative (form A), which aims to assess creative productions through drawings and compositions. It consists of three subtests: composing a drawing, finishing a drawing and parallel lines. In the first one, composing a drawing, the child is asked to make a drawing from a given shape, consisting of a piece of colored adhesive paper. The paper, according to the author, could resemble a tear, an egg or a pear. It should be noted that if the child does not provide a title, it cannot be graded.

The objective is to give a purpose to something that previously had no purpose. The skills that are assessed with this first subtest are: a) originality, consisting of considering novel, unfamiliar and unusual responses; and b) elaboration, which refers to the amount of detail that the child adds to the drawing in order to embellish it.

The second subtest, finishing a drawing, consists of 10 strokes, from which the child has to use them to make different drawings and give them a title. Elaboration (number of details added to the drawing), originality (unusual and unconventional answers), flexibility (variety of categories in the answers) and, to a lesser degree, fluency (number of drawings with title made) are evaluated. The third and final subtest, parallel lines, consists of 30 pairs of parallel lines. The objective is to make as many drawings as you can from the lines. It measures fluency (ability to make multiple associations from a single stimulus); flexibility (ability to change the pattern or structure of compositions), originality (ability to make different and unfamiliar structures) and elaboration (ability to add detail to structures made with parallel lines) (Torrance, 1974).

Procedure

After obtaining the corresponding permissions from the school and informed consent from the parents, we proceeded with the application of the test battery. All tests were conducted in schools - sports facilities and classrooms - and were supervised by in-house researchers, with teachers present. In three separate sessions, 48 hours apart, a team of researchers previously trained to perform the different tests evaluated the participants.

During the first session, the standing long jump test (two attempts, the best attempt was recorded) and the Leger test (one trial) were recorded and then the children indicated their level of perceived exertion using the Borg scale (Borg, 1970). Prior to the test sessions, the children performed a typical warm-up consisting of five minutes of low-intensity running and five minutes of general exercise (i.e., jumping jacks, leg lifts, lateral running, and front-to-back arm rotations). The children were motivated and encouraged to achieve the best possible score in each test. In a third session, the students were evaluated on the different questionnaires. The questionnaires were completed individually and in the presence of the researchers, respecting the confidentiality of the data and clarifying any doubts that arose. Data collection was carried out during the State of Alarm, in this case from April to May 2021.

Intervention

Once the feasibility of the installation of the bike desks (see Figure 1) had been verified and it was ensured that their use did not interfere with the normal development of the different classes, 3 bike desks, model Wakeman Under Desk Bike Pedal Exerciser, were installed in different classrooms in such a way that the 3 participating classes, 4th, 5th and 6th grades of Primary Education, were represented.

Figure 1

Bike Desk Illustration

The GE participants performed 4 times per week (Monday, Tuesday, Thursday and Friday) a static pedaling program during classes between 4 to 5 weeks. Each classroom had an established pedaling schedule that coincided with the subjects taught in the classes, being supervised at all times by the teachers of each subject. The teachers and students were previously informed about the protocol and the operation of the pedelecs, being of vital importance to record the data obtained from each student in their personal file, provided by the researcher, after the hour of pedaling. The time spent pedaling, calories burned and number of laps pedaled were recorded on the card. In addition, an intensity program was designed by regulating the pedaling, with the first week of pedaling being a less intense level, the second and third weeks a higher level and the last two weeks the intensity was increased even more. During these 5 weeks, the control group did not perform any intervention program.

Statistical analysis

Data were analyzed using SPSS, v.19.0 for Windows (SPSS Inc, Chicago, USA). USA) And the significance level was set at $\alpha = 95\%$. Data are shown as descriptive statistics including mean, standard deviation (SD) and percentages. Normal distribution and homogeneity tests (Kolmogorov-Smirnov and Levene, respectively) were performed on all data before analysis.

A chi-square and Student's t-test were used to compare demographic variables between groups. A 2x2 analysis of variance (ANOVA) with repeated measures (measure x group) was performed for the dependent variables (school aptitude, creativity and physical fitness). In addition, the effect sizes for group differences were expressed as Cohen's d (Cohen, 2013). Effect sizes are reported as: trivial (<0.2), small (0.2-0.49), medium (0.5-0.79) and large (≥0.8)

Results

Table 1 shows the descriptive results of the CG and SG in terms of age, anthropometric variables and mean number of steps taken during the intervention protocol. No significant differences were observed between groups.

Table 1

Age, anthropometric measurements and level of physical activity by sexes

	GC Mean (DT)	GE Mean (DT)	p-value	Cohen's d
Age	10.73 (0.87)	10.77 (0.73)	0.878	0.051
Weight (Kg)	40.73 (11.29)	40.03 (9.92)	0.855	0.067
Size (cm)	143.65 (12.56)	143.50 (9.84)	0.970	0.013
BMI (Kg/m^2)	19.17 (2.99)	18.99 (2.46)	0.859	0.067
Daily steps	7376.18 (1935.15)	7665.15 (2369.68)	0.791	0.137

Note. CG= control group; EG= experimental group.

Table 2 shows the pedaling values during the intervention.

Table 2

Descriptive statistics of pedaling performance during the intervention in the GE

	Minimum	Maximum	Media	Standard deviation
Weeks of pedaling (days)	4,00	5,00	4,55	0,41618
No. of pedal strokes (cycles)	708,90	5247,05	2394,37	1326,79
Pedaling time (min)	17,047	44,25	31,58	8,58
Pedaling frequency (cycles per minute)	40,94	122,19	71,17	24,63

Table 3 shows the pretest and posttest results of the CG and SG for both physical fitness and cognitive variables. In the group time analysis it is observed that only the CG experiences a significant improvement in the calculation dimension and in the total score of the TEA. In turn, both groups show a significant improvement in horizontal jump performance.

Table 3

Results on physical and cognitive fitness variables

Groups	Groups	Pre-test Mean (SD)	Post-test Mean (SD)	p-value (Time x group)	Cohen's d
Léger test (period)	GC	3.23 (0.88)	3.36 (0.95)	0.607	0.141
	GE	4.27 (2.00)	4.16 (1.73)	0.672	0.058
p-value (Group x time)		0.047	0.089		
Cohen's d		0.698	0,593		
Horizontal jump (cm)	GC	123.05 (15.38)	134,68 (15.39)	0.000	0,755
	GE	128,22 (19.81)	136,00 (21.01)	0.001	0.381
p-value (Group x time)		0.381	0.829		
Cohen's d		0.300	0.074		
Borg scale (0-10)	GC	7.13 (2.85)	7.78 (2.27)	0.487	0.252
	GE	6.97 (7.05)	6.50 (2.06)	0.629	0.090
p-value (Group x time)		0.863	0.080		
Cohen's d		0.030	0.606		
Vocabulary	GC	10.52 (3.50)	11.15 (3.76)	0.223	0.173
	GE	9.44 (3.69)	8.83 (3.95)	0.251	0.159
p-value (Group x time)		0.367	0.076		
Cohen's d		0.309	0.619		
Reasoning	GC	17.05 (5.43)	18.15 (5.39)	0.320	0,203
	GE	17.11 (4.15)	17.94 (5.36)	0.464	0.173
p-value (Group x time)		0.971	0.905		
Cohen's d		0.012	0.040		
Calculation	GC	37.10 (13.30)	43.21 (9.43)	0.003	0.529
	GE	38.77 (11.88)	39.72 (8.15)	0.635	0.093
p-value (Group x time)		0.690	0.238		
Cohen's d		0.135	0.406		
Total TEA (0-132)	GC	85.21 (22.76)	94.63 (18.61)	0.000	0.453
	GE	84.00 (18.66)	86.27 (16.83)	0.318	0.127
p-value (Group x time)		0.861	0.162		
Cohen's d		0.059	0,483		
Torrance test	GC	190.05 (62.57)	194.47 (57.89)	0.569	0.073
	GE	184.38 (60.97)	195.11 (56.72)	0.184	0.182
p-value (Group x time)		0.782	0.973		
Cohen's d		0.094	0.011		

Discussion and conclusions

Finally, the conclusions of the article will be presented in a last section, followed by the main conclusions. Where appropriate, limitations and proposals for continuity will be included.

The main objective of this research was to analyze the effect of 5 weeks of interactive pedaling during regular school classes on physical fitness, school skills and creativity in primary school children. Our main finding was that the hypothesis put forward could not be demonstrated. The proposed protocol was insufficient to bring about significant improvements in physical fitness and cognitive abilities beyond those that would have occurred due to the school process. It is noteworthy that even the CG improved the total score on the TEA.

Another relevant finding was that considering that children and adolescents who make <12 000 steps/day could be considered physically inactive (Colley et al., 2012), the children of both the GE and GC could be classified in this way since they performed over 7500 steps per day. However, the introduction of the pedelec during the classes increased the weekly physical activity levels of the CG participants by 126 minutes on average. In this way, they have been able to comply with one of the main WHO recommendations regarding physical activity, which is to perform at least an average of 60 minutes of moderate to vigorous intensity physical activity per day.

Although there are previous studies demonstrating the acute (Berrios Aguayo et al., 2019; Latorre Román et al., 2018; Peruyero et al., 2017) and chronic effect (Aadland et al., 2019; Ludyga et al., 2018; Latorre et al., 2021) of physical activity on cognitive processes, these studies have been conducted outside the dynamics of the formal school classroom, i.e., either at recess or between classes, or after school. In addition, other previous studies showed no significant effects of PA on cognitive processes. Kvalø et al. (2017) found no significant differences in children aged 10-11 years who performed physically active academic classes, physically active breaks, and physically active homework for 10 months in their EF. In addition, Donnelly et al. (2016) reported that no studies examining the use of PA breaks in the classroom showed positive results on academic achievement.

Although the results of our study are in line with the findings provided by Sui et al., (2019) in a recent review and indicate that active workstations do not appear to decrease workplace performance; although bicycle workstations may decrease some aspects of productivity and performance, but this could be due to unfamiliarity with the workstations. Similar to the findings of this study, other authors noted that low-intensity cycling during a university course maintained students' academic performance and possibly reduced weekly sedentary behavioral time (Joubert et al., 2017). Recently, a study with Spanish secondary school students showed that after 4 weeks of pedaling in the mathematics class, 4 times a week, there was an improvement in the performance of the Leger test but not in mathematical competence (Polo-Recuero et al., 2020).

A possible explanation for the results of this study could be due to the design of the activity, a dual activity (Dual Task paradigm), in which it has been previously shown that one of the two activities, physical or cognitive, is impaired. Thus, coordination of a motor and cognitive task may result in decreased performance on one or both tasks, relative to performance on each task separately (Schott & Klotzbier, 2018). Dual tasks during locomotion, for example during walking, when people are asked to walk and simultaneously perform another cognitively demanding task such as reciting words or calculations, may represent a new methodological approach to the assessment of brain function via cognitive-motor interference (Klotzbier & Schott, 2017; Montero-Odasso et al., 2014). Two theories have been used to explain the effects of dual-tasking on gait, the capacity trade-off theory proposes that attentional resources have limited capacity and must be shared between two tasks and the bottleneck theory which proposes that two tasks being performed simultaneously can only be performed sequentially which in turn can lead to a decrease in performance on one or both of the tasks (Hagmann-von Arx et al., 2016). That is, there is a worsening of performance, known as dual-task cost, i.e., there is a reduction in performance in dual-task performance, as compared to single-task performance) (Rabaglietti et al., 2019).

According to Gallotta et al., (2014) further studies, of an ecological nature, testing different components of the training load (exercise duration, exercise intensity, physical condition of the participants and the specific type of physical exercises) may be needed to elucidate the true effect of physical activity on the cognitive processes of schoolchildren. In addition, previous studies were very diverse, the duration of the interventions ranged from 8 weeks to 3 years, occurring through increased PA, with physical activity lessons in the classroom, PA breaks in the classroom, additional PA at school, an after-school fitness program, in laboratory or school settings (Donnelly et al., 2016).

Finally, it is worth mentioning the recent review by Guirado et al., (2021) in which they highlight that there is a 36% increase in energy expenditure for the "cycling desks", in turn the children increased inhibitory control and selective attention capacity while pedaling on the desk. Although these same authors indicate a heterogeneous quality of design and outcomes that limited comparisons and conclusions for each "active desk"; yet despite the lack of a robust methodology for the included studies, active desks appear to be a promising classroom intervention for improving health-related outcomes.

One of the main limitations of this study was the high "experimental mortality" due to the confinements produced in the School Center by the COVID-19 pandemic, which reduced statistical power and the possibility of a more prolonged intervention. It should be noted that it is not possible to control the interventions because the subject is not part of the center, and this could influence the results obtained. In addition, external validation problems can be distinguished since it is focused only on one school and on a not very wide age range. However, as strengths of this study, we highlight the fact that it was possible to carry out all the planned tests in spite of the inconveniences, so that it was possible to complete the research.

In conclusion, and in accordance with (Torbeyns et al., 2017) as the implementation of pedelecs in the classroom did not interfere with the academic performance of schoolchildren, this strategy can be seen as an effective means to reduce sedentary lifestyles in the classroom and at the same time it could improve the physical health of children, improving the time they spend sitting and thus complying with the global recommendations of the WHO. However, we appreciate that more intervention time is needed in order to obtain better results and to be able to compare with a larger number of subjects.

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