Systematic Review

The Effects of Bike Desks in Formal Education Classroom-Based Physical Activity: A Systematic Review

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Abstract: A systematic review of the research conducted on classroom-based physical activity using bike desks, a school health prevention strategy. To our knowledge, this is the first systematic review of bike desks effects on formal education students. Articles from two databases, Web of Science and PubMed, were analyzed according to PRISMA. The quality of each study was analyzed. After the exclusion criteria, eight articles were fully assessed based on six criteria: (1) author and year, (2) setting and sample, (3) duration, (4) outcomes measurements, (5) instruments and (6) main results. The results show how the interventions are mainly in secondary education and university, and most of them are quantitative studies of short-term interventions. Physical activity is the most frequently variable assessed, using logs, questionnaires and objective methods such as accelerometry and heart rate monitoring. Based on all the studies, it is feasible to implement bike desks in the classroom during theoretical lessons. The weaknesses are related to small samples and the use of different instruments to measure. In conclusion, this systematic review compiles the current information about bike desks in order to inform teachers and administrators for the implementation of bike desk in their schools. They should consider bike desks' strengths and weaknesses.

Keywords: physically active learning; active schools; health; adolescents; inactivity; sedentarism

1. Introduction

More than 80% of worldwide adolescent population is insufficiently physically active [1] and more than a quarter of adults do not get enough physical activity [2]. Fortunately, despite the fact that the students of any level spend most of their day seated in a desk, during extracurricular leisure time, students practice different physical activities and sports. However, their activity depends not only on their will but also on the accessibility of its resources. Because school is the place where they spent at least half of their waking day [3], it is the only and ideal place to ensure that every student exercises [4], increasing the amount of physical activity they do [5] and implementing health prevention strategies [6].

Few universities require lifetime fitness/wellness courses for their students [7]. Regarding elementary and secondary schools, physical education is the main subject based on physical activity throughout the world. This important subject entails plenty of physical activity [8], health [9,10], cognitive [11] and academic [12] benefits for the student. However, the time dedicated to physical education is insufficient [13,14] and it does not comply with

the World Health Organization recommendations to perform at least 60 min of moderate to vigorous intensity physical activity (MVPA) daily, including strength activities three days per week for children and teenagers [15]. Undergraduates are considered adults, hence, they should perform at least 150 min of MVPA, or 75 min of vigorous intensity physical activity throughout the week [15].

On account of this, schools have sought innovative strategies to increase the level of physical activity during school hours and to reduce sedentary time. Figure 1 summarizes the school physical activity possibilities of the students.

Figure 1. Strategies to increase children’s and adolescents’ physical activity.

Physically active learning [16] integrates movement into academic activity in two different ways. On the one hand, the physically active lessons, with a modified methodology or active pedagogical strategies, transmit academic content through movement. In order to do this, the teacher modifies the teaching methodology to incorporate movement, either throughout the whole session or just through active academic breaks. These lessons bring positive outcomes, the main one is the increase of the students’ physical activity level [17–19], although there is limited evidence that this physical activity is MVPA, which is recommended for its health benefits [20]. In addition, benefits have been found in learning mathematical content [21], concentration and attention [22], fluid intelligence [23], academic performance [24,25], behavior [26,27], cardiorespiratory fitness [28] and enjoyment [29].

On the other hand, classroom-based physical activity could be achieved by establishing kinesthetic classrooms with active desks. These classrooms integrate different physical activity devices, hereinafter known as active desks, in the traditional classroom. The active desks allow students to attend while they are doing physical activity. According to the review [30], active desks are a promising element in schools. They are based on Howard Gardner’s multiple intelligences model [31] and combine academic content learning with movement during active lessons. It is remarkable that active desks do not seem to interrupt the classes and it tends to not reduce instruction time, but it requires a financial investment. There are different models of active desks [32–34]. Bike desks consist of a resistance that allows pedaling on site and have been named under different denominations: bike pedal desks/exercisers, bicycle/cycling workstations, stationary bicycle/cycle under the desks.

Bike desks have been satisfactorily implemented in workplaces such as offices [35–37] and libraries [38,39]. Moreover, the devices have been evaluated under laboratory conditions with undergraduates [40,41] and preadolescents [42] with positive effects on learners’ affective state and no detriment on academic or cognitive performance.

This paper aims to systematically review the available studies describing bike desks interventions in school, high school or university formal courses.

2. Materials and Methods

The study was carried out based on the PRISMA statement guidelines [43] and registered in the International Prospective Register of Systematic Reviews (PROSPERO) (identifier ID: CRD42020186985).

Bike desks studies in formal education were searched in Web of Science and MEDLINE (via Pubmed). The search was done during May 2020 using the Boolean search method. The search combined the following terms: “bike”, “bicycle”, “cycle”, “pedal”, “elliptical”, “cycling” combined with either “desk” or “workstation” and combined with either “school”, “class” or “student”. After the database searching was completed, two papers from additional sources were included.

Research articles were analyzed using the PICOS strategy criteria [44] to find projects or programs in which the students attended their traditional lessons using bike desks. Studies were required to be written in English or Spanish. All of them had to be published in a peer review journal or to be part of a PhD thesis or dissertation. Since bike desks have been recently implemented in school contexts, it was decided to use the publication dates between 2014 and 2020 because back in 2014, a systematic review [32] stated that all the 16 studies found on the use of walking and cycling workstations investigated their use just in adults. Thus, there were no records of students using active desks. The inclusion criteria were (a) the populations included students (elementary, secondary or college), (b) interventions with bike desk in formal learning lessons, (c) study designs carried out in schools and (d) at least physical activity or feasibility outcomes of the intervention should be reported. Working adult populations, non-formal learning contexts and studies conducted in labs were excluded.

The main investigator searched in databases to extract the results, eliminating the duplicates. Then, two investigators autonomously analyzed the articles to check if they met the eligibility criteria. They had a 100% agreement selecting the papers about formal learning using bike desks. Finally, two researchers reviewed the whole investigation process.

3. Results

Figure 2 shows the PRISMA consort flow diagram that describes the search strategy and selection process. A total of 116 manuscripts were identified, of which 68 were duplicates. Subsequently, we screened title and abstract of 48 manuscripts, excluding 32. Eight articles were additionally excluded after reading the full text and verifying that they did not meet the inclusion criteria.

To analyze the quality of the selected studies, the PEDro Scale [45] was applied, and the results are described in Table 1. The average methodological quality score was 56.06%. Logically, substantial differences were found between the experimental studies' scores [46,47] and quasi-experimental studies' scores [48–51]. Two studies [46,47] reached a score between 70% and 100%, two studies [48,50] were between 50% and 70%, and the two studies [49,51] that could not count on a control group could not reach the 50%. The blinding condition of the studies requested in items 5 and 6 was not accomplished for any of the studies. All of the studies are educational investigations with students (subjects) and teachers (therapists) and that makes this condition impossible. In addition, just one study [47] achieved item number 8 because the dropouts or exclusion rate was high in most of the studies or was not reported. Item 1 was the category where the highest quality of the study was found because all of the studies specified the eligibility criteria of their sample.

Figure 2. Flow diagram of the search strategy and selection process.

Table 1. Quality of the included studies.

Author (Year)	1	2	3	4	5	6	7	8	9	10	11	Score
Torbeyns et al. (2017) [46]	✓	✓	✓	✓	x	x	✓	x	✓	✓	✓	8
Fedewa, Abel et al. (2017) [50]	✓	✓	✓	x	x	x	✓	x	✓	✓	✓	7
Fedewa, Cornelius et al. (2017) [49]	✓	x	x	✓	x	x	x	x	✓	x	x	3
Joubert et al. (2017) [47]	✓	✓	✓	✓	x	x	✓	✓	✓	✓	✓	9
Fedewa et al. (2018) [51]	✓	x	x	✓	x	x	x	x	✓	x	x	3
Cornelius (2018) [48]	✓	✓	✓	x	x	x	✓	x	✓	✓	✓	7

Note: ✓ = yes; x = no, non-applicable or insufficiently described. The quality of Mueller, et al. (2017) [52] and Yu et al. (2019) [53] couldn't be analyzed on account of their non-experimental design. Note: PEDro Scale items [45]: 1: eligibility criteria specified; 2: random allocation; 3: concealed allocation; 4: groups similar at baseline; 5: subject blinding; 6: therapists blinding; 7: assessor blinding; 8: less than 15% dropouts; 9: intention-to-treat analysis; 10: between-group statistical comparisons; 11: point measurements and variability data.

A total of eight manuscripts were considered eligible for this systematic review. Table 2 describes all included studies about bike desks in formal education. The use of bike desks in the classroom is recent because all the studies were published the last four years, between 2017 and 2019. Most of them were conducted in the United States, followed by one each in Belgium [46] and Canada [52]. Half of the papers [46–48,50] compare an intervention group with a control group. Two studies [46,47] are experimental designs with randomized controlled trials. Another two studies [48,50] are quasi-experimental designs with a true control group, two more studies [49,51] are a pre-post intervention testing baseline and the last two papers [52,53] are descriptive studies. Most of the studies' samples ($n = 7$) are students and there is only one study that surveys teachers [52]. The sample sizes are diverse, the smallest [50] gathers 17 students and the largest [48] includes 114 participants. Experimental and quasi-experimental interventions with student sample, have a mean of 52.83 students. Most of the research ($n = 6$) is based on high school students, and just one paper includes undergraduates [47] and it must be considered that one is carried out with special education high school students [51]. The intervention duration of all the studies that comprise students is less than a four-month period: intervention timelines ranged from 60 days to four months. In many of the studies, students had access to bike desks in certain lessons a week for a specified period and in just two studies the time access was flexible [50,51].

Table 2. Included studies.

Author, Year	Setting Sample	Duration	Outcomes Measurements	Instruments	Main Results
Torbeyns et al. (2017) [46]	Belgium High School $n = 44$ students 14.3 ± 0.6 years 47.7% males	15 weeks 4×50 min per week	Physical activity Anthropometric Aerobic fitness Academic and cognitive performance. Brain function	Accelerometer PAQ-A Body analyzer 20 m shuttle run RAVLT RCPT Stroop test EEG	↑ Energy expenditure BMI changes ↑ Aerobic fitness No significant differences
Fedewa, Abel et al. (2017) [50]	US High School $n = 17$ students 14–18 years	60 days. Flexible access to bike desks	Feasibility Physical activity	Interview Questionnaire Accelerometer Student log	More advantages than limitations ↓ Sedentary time MVPA

Table 2. Cont.

Author, Year	Setting Sample	Duration	Outcomes Measurements	Instruments	Main results
Fedewa, Cornelius et al. (2017) [49]	US High School $n = 80$ students 16.06 years 53% males	4 months 5×20 min per week	Feasibility Physical activity Behavior	Survey HR monitor Momentary Time Sampling	Pros and cons ↑ HR and calorie expenditure No effects
Joubert et al. (2017) [47]	US University $n = 21$ students 19–24 years 29% males	12 weeks 3×50 min per week	Feasibility Physical activity Academic performance	Survey Student log Standardized rubric Test	Not disruptive. ↑ Physical activity ↓ Sedentary time. No significant differences
Fedewa et al. (2018) [51]	US High School $n = 41$ students 14.97 years 80% males	16 weeks Flexible access to bike desks	Acceptability Physical activity Behavior	Questionnaire HR monitor Student log Momentary Time Sampling	Positive ↑ HR and energy expenditure No significant differences
Cornelius (2018) [48]	US High School $n = 114$ students 16 ± 1.25 years 67% males	14 weeks 3×50 min per week	Self-efficacy Physical activity On-task behavior	SES & SEES HR monitor PAQ-A and Log Momentary Time Sampling	No differences ↑ HR Light physical activity No differences
Mueller, et al. (2017) [52]	Canada Kinder-Grade12 $n = 107$ teachers	Sparks Fly program	Feasibility Teacher perceptions	Survey	Pros and cons
Yu et al. (2019) [53]	US High School $n = 28$ students	3 months (daily basis)	Feasibility Physical activity	Student interviews Student log	Positive attitudes ↑ Physical activity

Table 3 presents every outcome assessed depending on the study different variables have been examined. Seven out of eight studies examined the effects of bike desks on students' physical activity [46–48,50,51,53]; six studies analyzed the feasibility or acceptability of bike desks [47,49–53]; five studies focused on academic-related outcomes [46–49,51]; and just one focused on brain function [46], anthropometrics [46], aerobic fitness [46] and self-efficacy [48].

Table 3. Outcomes assessed.

	[46]	[50]	[49]	[47]	[51]	[48]	[52]	[53]
Physical Activity	✓	✓	✓	✓	✓	✓	-	✓
Feasibility and/or acceptability	-	✓	✓	✓	✓	-	✓	✓
Academic related	✓	-	✓	✓	✓	✓	-	-
Brain function	✓	-	-	-	-	-	-	-
Anthropometrics	✓	-	-	-	-	-	-	-
Aerobic fitness	✓	-	-	-	-	-	-	-
Self-efficacy	-	-	-	-	-	✓	-	-

Note: ✓ = outcome assessed; - = outcome non assessed.

3.1. Physical Activity

The main devices to assess physical activity were accelerometers [46,50] and heart rate monitors [48,49,51]. These objective methodologies were completed in two studies with the PAQ-A questionnaire [46,48]. There were five studies that gathered bike desk screen data about distance, time, speed or calories in student logs [47,48,50,51,53]. All the studies found positive outcomes of bike desk use in formal education: higher energy expenditure [46,49,51], less relative time in sedentary activities [47,50], and higher average heart rate [48,49,51]. Nevertheless, only two studies considered physical activity intensity. On one side, one study [50] found that there is more MVPA, and on the other side, another study [48] claims that students only engage in light physical activity. Therefore, bike desks seem to help increase physical activity, but further research is needed to discover if that exercise is enough to reach MVPA, the physical activity recommended for children and adolescents.

3.2. Feasibility and/or Acceptability

Feasibility and bike desks acceptability were measured with quantitative and qualitative methods. Most of the studies [47,49–52] applied objective questionnaires or surveys, and there were two studies [50,53] that used interviews. The literature has encountered some shortcomings such as the comfort of the bike seat [50] and difficulties riding a bike and engaging in class simultaneously [49,52]. However, the analyzed studies show more positive outcomes than limitations, for example, students' motivation and enjoyment of the bike [48–50,53], active learning with academic benefits [48,52,53] or higher awareness of daily physical activity [47,53].

It has to be noted that, depending on the study, bike desks models are different and this could affect the feasibility with scholars. Most of the studies use a bicycle workstation such as FitDesks® (FD Products, Kernersville, NC, USA) [47,49–51], LifeSpan® C3-DT5 (PCE Fitness, Charlotte, NC, USA) [46] or Sparks Fly® (Run For Life Inc., Waterloo, ON, Canada) [52]. Even though other models of bicycle workstations would perhaps be more acceptable in a high school setting [49], and the stationary bike pedals under the traditional desk used in two studies [48,53] could be a better option, one of them was a DeskCycle™ (3D Innovations, Denver, CO, USA).

3.3. Academic-Related Outcomes

Academic achievement, cognitive performance, and academic behavior are the main variables employed in the previous literature to assess academic outcomes. There were only two studies that focused their attention on academic achievement and cognitive performance using standardized tests [46,47]. In addition, one study [46] made use of electroencephalography to analyze brain function. Three studies [48,49,51] measured the students' on-task or/and off-task behavior. In all of them, Momentary Time Sampling instrument were used, which is an interval recording strategy that involves observing whether a behavior occurs or does not occur during specified time periods. No significant differences were found in the use of bike desks related to academic achievement, cognitive performance and behavior.

3.4. Brain Function, Anthropometrics, Aerobic Fitness and Self-Efficacy

It is difficult to draw clear conclusions about brain function, anthropometrics, aerobic fitness and self-efficacy, since there is just one study published of each of them. No significant differences were found in students' brain function [46] and self-efficacy [48] after pedaling in a bike desk, but it seems that bike desks have positive outcomes regarding student's anthropometric and aerobic fitness [46]. Despite the aforementioned potential, future studies should investigate those variables.

4. Discussion

Classroom-based physical activity is a contemporary strategy to keep students active while they are learning, and active desks are a good way to achieve it. They seem to be a feasible alternative to fight against the unhealthy traditional seating sedentarism in classrooms. Depending on the type of dynamic seating device implemented, the effects are different [34]; standing desks have been deeply studied in formal education and there are systematic reviews about them [30,54].

To our knowledge, this is the first systematic review of bike desks' effects on students' physical activity and academic outcomes. Bike desks' feasibility and acceptability seem positive in formal education, and these conclusions agree with the ones drawn about standing desks in schools [55].

Classroom-based physical activity interventions with other active workstations have been implemented with elementary students previously [56], however, no studies have employed bike desks within school children under 13 years. It is well known their use with children in many international programs such as "Read and Ride" or the "Sparks Fly Program" [52], so it would be appropriate to study the effects of bike desks on this young population.

Overall, the results of this systematic review prove the efficacy of bike desks in several variables: higher energy expenditure, less sedentary time and higher heart rate. Likewise, standing desks in schools are conducive to some positive effects on students' physical activity levels and energy expenditure [57], which leads to less sedentary time [54,58]. Nevertheless, there are different variables analyzed that make the comparison between the included studies difficult (i.e., average calories, cycle time and distance, heart rate, sedentary time, MVPA time). Objective methods such as accelerometers and heart rate monitors seem to be the best options to quantify and evaluate physical activity [59]. Furthermore, the teacher or leader that guides pedaling should give the same indications (i.e., speed, resistance and Borg perceived exertion scale) to participants.

The implementation of cycle workstations has no effects on students' academic-related outcomes (academic performance, cognitive performance and behavior). According to a systematic review [34], most of the studies agree that there are no significant academic differences between students attending lessons on active desks compared to traditional desks, and it disclosed a better on-task and less off-task behavior. Standardized testing to measure academic performance has been used broadly in physical activity interventions with schoolchildren [60]. Momentary Time Sampling and other direct observation methods provide objective information during classroom-based physical activity lessons [18,26].

Some limitations must be considered. Research evidence is limited, and three out of eight of bike desk studies available have been developed for the same main investigator. To be rigorous and to generalize conclusions, subsequent investigations are required to determine the long-term health benefits, and they should include both treatment and control conditions with clear baseline participants characteristics. In addition, physical activity performed with bike desks could change physical activity patterns during leisure time, follow-up investigations should be done to control this variable. Furthermore, novelty effect should be eliminated, and longer term use of active desks should be observed to check adhesion and motivation to these devices. In addition, in future investigations, sex differences could be an important parameter to consider, as well as including in the studies students with attention deficit hyperactivity disorder, low grade students, obese students, inactive students or any other special population.

5. Conclusions

Based on the findings of this systematic review, we suggest that, overall, emerging bike desks seem to be feasible and promising on formal education lessons and could impact students' physical activity profile while they are learning, with no detriment on academic performance. Administrations and schools should consider different aspects before implementing kinesthetic devices to achieve classroom-based physical activity, such

as target population, feasible subjects, bike desk models and brands, impact in health variables and physical activity intensity. Even though its application is viable, it requires commitment from its users and higher economic investment than other strategies such as active recess or active breaks. Future studies are necessary to compare the effects of bike desks on students' anthropometrics, aerobic fitness and self-efficacy and to confirm the health prospective benefits.

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