

Classroom Active Desks

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Classroom active desks refer to the desks placed in the classroom and can be moved in teaching activities. This entry was to examine the effects of active desks in the school setting on sedentary behavior, physical activity, academic achievements and overall health among children and adolescents aged 5–17 years.

Keywords: academic achievements ; active desks

1. Introduction

Concerns and research regarding the effects of sedentary behaviors and physical inactivity on overall health have been growing for the last decades, leading nowadays to a better identification of their independent and joint implications [1][2]. While sedentary behaviors is defined as any waking behavior characterized by an energy expenditure ≤ 1.5 metabolic equivalents, while in a sitting, reclining or lying posture [3][4], physical inactivity is typically defined as “the non-achievement of physical activity guidelines” [5]. Both sedentary behaviors and physical inactivity have substantially increased in our societies, with physical inactivity being identified as the main cause for about 1.6 million deaths worldwide [6] and leading to a public health cost of \$53.8 billion per year [7]. Due to their important implication in the risks of all-cause mortality and cardio-metabolic morbidity as well as in some cancer occurrence [8], both sedentary behaviors [9][10] and physical inactivity [11][12] are of public health concern today.

In children and adolescents, it has been found with device-based measurements that daily sitting time takes over 50% of the waking day at 7 years and 75% at 15 years [13]. This high level of sedentariness, combined with the fact that about 80% of children and adolescents are inactive (i.e., not reaching the physical activity recommendations) [14][15], led some scientists to propose the existence of what they called a “Sedentary & Inactive” profile [16]. Not only physical inactivity and sedentary behaviors have been found to be associated with early metabolic and cardiovascular risk in children and adolescents [17][18][19][20][21], they have also been found to be related to a decrease in cognitive performance and academic achievements [22][23][24].

Knowledge and behaviors developed during childhood have been shown to influence their future behaviors as adults [25]. In particular, children’s physical activity and sedentary behaviors have been shown to not only determine their actual health but also their adolescent and adult behaviors and health [26]. Since children spend at least one third of their waking time in class [27], school appears as an ideal setting to promote health and induce behavioral change [28]. Targeting school time and the school place to promote healthy active behaviors necessitates however to face the highly sedentary nature of the children’s class time. In that context, the literature shows a growing number of experiments trying to implement interventions aimed at breaking and reducing this sedentary time during class [29][30]. The use of active desks in the classroom (e.g., standing desks, sit-to-stand desks, cycling desks, stability balls) has been especially studied [31][32][33][34], with studies showing for instance that sit-to-stand desks seem to reduce sedentary time in the classroom [31] or increase energy expenditure with the use of bike desks [34]. These studies are providing some promising results and our aim is to conduct a systematic analysis of these works to have a better understanding of their effects.

Table 1. Active desks characteristics and range of price.

Active Desk Type	Description	Range of Price (USD)	Pictures
Upright active desk	Corresponds to standing desk, sit-to-stand desk or stand-biased desk.	150–900	 
Cycling desk	Is a stationary bike with a desk enabling individuals to work while cycling	200–900	
Stability ball	Replace the traditional chair with a stability ball on individual desk	10–100	

2. Search Strategy

A literature search was conducted for studies from year 1990 to October 2020 using the following electronic bibliographic databases: PubMed, ScienceDirect, ResearchGate, Google Scholar and Medline (Cochrane Library). The search terms included the key words “desk* or workstation* or work station” AND “treadmill OR pedaling OR cycling OR bicycl* OR bik* OR active OR exercise ball* OR swiss ball* OR stability ball* OR dynamic seating OR active sitting OR standing OR stepping OR stand up OR position, standing OR standing position* OR sit-to-stand OR sit stand OR stand/sit OR stand biased OR adjustable furniture OR height adjustable” AND “school* OR class* OR child* OR student* OR academic institution”. To identify articles potentially missed during the literature search, reference lists of candidate articles were reviewed.

3. Description of Studies

The PRISMA flow diagram presented in [Figure 1](#) summarizes the study selection process. The search strategy initially found a total of 1677 references after removing duplicates. A total of 1635 articles were excluded after screening of titles and abstracts. Full text copies were obtained for 44 articles; of which 25 articles matched the inclusion criteria and were thus included in this systematic review. The main reasons for studies exclusion among the remaining were: (1) study design did not meet inclusion criteria ($n = 8$); (2) intervention did not use an active desk ($n = 5$); (3) population was not children without health issues ($n = 3$); (4) full texts were not available ($n = 2$); and (5) active desks were already integrated in classroom ($n = 1$). One article included two different study designs ^[31].

Ten studies were randomized controlled trials (RCT) ^{[30][31][33][34][35][36][37][38][39][40]} with four pilot studies ^{[30][31][36][37]}; seven were non-randomized controlled trials ^{[31][41][42][43][44][45][46]} with four pilot studies ^{[31][44][45][46]}; four were non-randomized trials ^{[47][48][49][50]} with two pilot studies ^{[48][49]}; one was a randomized trial ^[51] and four were crossover studies ^{[32][52][53][54]}.

Among the included studies, 19 were conducted among primary school children aged 6–12 years [31][32][33][35][47][36][41][37][42][43][48][52][44][53][54][39][46][50][40], five took place among secondary level adolescents aged 12–17 years [30][34][53][39][50] and Verloigne et al. [38] enrolled children in both levels aged 10–16 years.

Two studies included boys only [32][52], three did not specify the gender [30][36][49] and the rest of the studies included both boys and girls [31][33][34][47][36][37][42][43][48][49][51][44][53][45][54][38][39][46][50][40].

Twenty studies assessed upright active desks (i.e., standing desk, sit-to-stand desk and stand-biased desk) [31][32][35][47][36][41][37][42][43][48][49][52][51][44][53][45][54][38][39][46], three cycle desks [30][34][46] and two used stability balls [33][40]. Active desks have been described in Table 1.

In twenty-one studies, active desks were allocated to every individual [31][32][33][34][35][47][36][41][43][48][49][52][51][44][53][45][54][39][46][50][40]. Verloigne et al. [38] implemented three standing desks per classroom, Clemes et al. [37] provided six active desks in each class and Fedewa et al. [30] provided four active desks in interventional group. One study did not specify the number of implemented active desks [42].

All studies had an intervention duration from two weeks to two years. Verloigne et al. [38] suggested a rotation every half class while Clemes et al. [31] recommended to use active desks at least 30 min per day (Australian study) and one hour per day (English study). Some studies suggested also to practice active desks at least one hour per day [37][46] or for four class hours of 50 min per week [34]. Several studies did not indicate the active desks time and frequency use [48][52][44][50][55]. Some interventions enabled active desks to be free to use [30][35][47][36][41][43][48][49][53][45] or to use it for the entire school day [32][33][42][40]. In one study, active desks were only used for the evaluations [50].

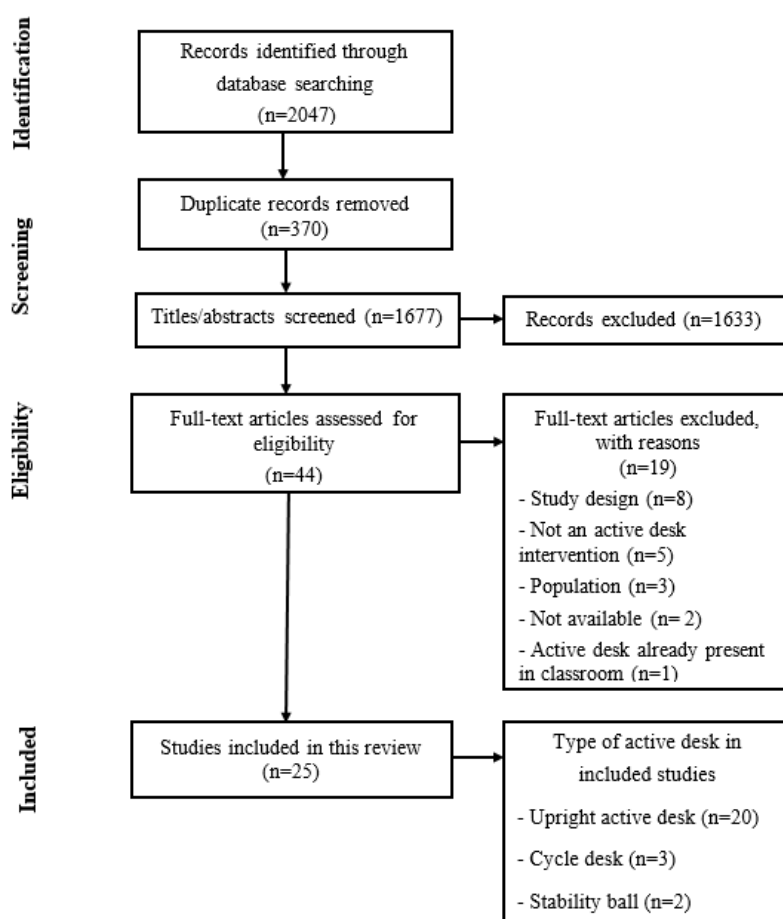


Figure 1. PRISMA flow chart

4. Data Synthesis by Outcome

4.1. Body Composition

Six studies assessed body composition when using upright active desks [35][47][36][37][48][39] and one with cycling desks [34]. However, one study did not detail their results on this outcome [35] (Table 6). Wendel et al. [39] found a significant difference in BMI for interventional group compared to the control group after two years of intervention (−5.24 for BMI percentile) (Table 3). Other studies did not report any change in BMI with the use of an upright active desk.

Torbeyns et al. [34] observed a significant effect of time for height, body weight, fat mass percentage and waist circumference without condition effect. However, traditional desks group reported a significantly higher BMI while cycling desks group did not find any difference.

4.2. Sedentary Behaviors

Thirteen articles using upright active desks assessed sedentary behaviors [31][32][41][37][43][52][51][44][53][45][54][38][46], while only one used cycling desks [30]. As presented in [Table 3](#), two studies observed that children, when using upright active desks, spent significantly less time sedentary than the control group, using objective measurements [43][54]. Other studies did not find any difference for the interventional group [52][45]. Moreover, Ee et al. [32] observed no significant difference for whole day sedentary time but reported a significant reduction in sitting time during school hours for the intervention group compared to the control group. Similar results have been reported in four other articles [31][37][53][45]. Additionally, four studies reported a reduction of sitting time between T0 and T1 for the intervention group [37][43][44][50]. Similar results have been found in another study but were not statistically significant [52][53].

Fedewa et al. [30] reported a decreased of 9.5% in sedentary time for the intervention group compared to the control group.

4.3. Physical Activity

Sixteen articles assessed physical activity using upright active desks [31][32][47][36][41][37][43][48][52][51][44][53][45][54][38][46], two with cycling desks [30][34] and one with stability balls [33]. Studies assessing the upright active desk effects on physical activity reported several different outcomes such as light physical activity, moderate-to-vigorous physical activity (MVPA), step counts, stepping, standing and walking time ([Table 3](#)).

For light physical activity, four studies reported no significant changes for interventional group compared to the control group [32][51][53][40][55]. For MVPA, studies found contradictory results while two studies did not find any change [32][52]. Kidokoro et al. [43] observed a significant increase in MVPA for the intervention group between pre- and post-intervention. Another study [54] found that MVPA decreased for the intervention group during school years but less than the control group. Additionally, they reported that the benefit of upright active desk was greater among students initially determined as less active.

Statistically significant increases were reported for the intervention group standing time in height studies [31][32][41][37][51][44][45][38][46]. Similar results have been reported but without reaching significance [52][53].

Regarding step counts, Benden et al. [47] reported an increase of this outcome without statistical analyses ([Table 3](#) and [Table 6](#)). In another study, they reported similar results at mid intervention but not at the end [36]. No significant effects were observed in two other studies [48][51]. In the article of Clemes et al. [31], the study in Australian school reported no significant effect while the British ones showed an increase for the intervention group in post intervention.

For stepping time a significant decrease was reported for the intervention group [38] or no effect [31][46]. One study [44] observed a significant increase while Clemes et al. [37] found similar results but no statistical analyses have been reported.

Torbeyns et al. [34] assessed the effect of cycling desks on physical activity with a questionnaire. Interventional group and control group decreased their physical activity time between pre- and post-intervention but no condition effect was observed. Despite the lack of statistical analyses ([Table 2](#) and [Table 4](#)), one study reported, with an objective measurement, an increase of light physical activity and MVPA for the intervention group compared to the control group [30].

One study using stability balls assessed physical activity and missed to observe any difference between the interventional group and the control group after the intervention [33]. Additionally, all groups decreased their physical activity level and their step count between pre- and post-intervention.

4.4. Energy Expenditure

Four studies assessed energy expenditure with the use of upright active desks [36][41][49][54] and two with cycling desks [30][34]. All upright active desks studies observed an increase between 15% and 25.7% in energy expenditure for interventional groups compared to control groups [36][41][49][54] ([Table 2](#)).

Cycling desk studies reported also an increase of energy expenditure. Torbeyns et al. [34] showed a significant increase in energy expenditure (36%) using cycling desks compared to traditional desks. Fedewa et al. [30] reported similar results without any statistical analyses (Table 3 and Table 6).

4.5. Physical Capacities and Cardiometabolic Health

Physical capacities were only evaluated in one study that used cycling desks [34]. The authors reported an increase in the performance during the 20 m shuttle run test in their interventional group compared to the control group (+0.6 interval) (Table 3). Moreover, there was a significantly lower rate of perceived exertion (RPE) in the interventional group compared to the control group after 22 weeks. For cardiometabolic health, only Clemes et al. [37] assessed blood pressure with the use of an upright active desks. They reported an increase in systolic blood pressure in the interventional group but the authors did not perform statistical analyses (Table 2 and Table 4).

4.6. Cognitive and Academic Performance

Seven studies assessed cognitive and academic performance when using upright active desks [37][49][52][44][45][38][39], two studies with cycling desks [34][50] and two with stability balls [33][40]. Concerning executive functions (working memory, inhibitor control, cognitive flexibility), visual working memory was assessed in two studies using upright active desk and two studies using cycling desks and no change was reported [34][45][39][46]. As detailed in Table 4, inhibitory control has been assessed in three studies, and the use of cycling desks shown to significantly increase the inhibitor control in the intervention group compared to the control group with an higher increase of accuracy for the intervention group (4.21%) [50]. One of the studies that used upright active desk reported an improvement in both reaction time and accuracy [46] while the other reported no significant change [49]. The reaction time for cognitive flexibility decreased after intervention in the study that used upright active desks [46].

Regarding to academic engagement and attention, two studies using upright active desks reported an increase in the intervention group compared to the control group [41][42] without any change in concentration and classroom management [33][37][38]. A study using stability balls reported more interaction time with teachers but the time working with other students or independently were reduced compared to the control group after intervention. Both groups observed improvement in mathematics and literacy but they were not related specifically to the intervention [40]. Mehta et al. [49] assessed several outcomes where they primarily observed a significant increase in cognitive performance with the use of upright active desks compared to traditional ones.

4.7. Fatigue and Musculoskeletal Pain Symptoms

Six studies, all with upright active desks, assessed fatigue and musculoskeletal pain symptoms [32][37][44][53][38][40]. Three studies reported no difference on those outcomes between upright active desks and traditional desks [37][44][38]. Significant changes have been reported in two studies [32][52] with a decrease of pain symptoms in the neck and shoulder area. Nonetheless, a study observed that 51% of children have experienced pain in legs and back area with the use of upright active desks [45] (Table 4).

4.8. Process Evaluation

Acceptability and feasibility have been assessed in several studies [30][41][37][43][44][45][38]; one was cycling desks [30] and others were upright active desks. One study reported retention rates of 100% for schools and 97% for children with an overall recruitment rate at 33% [37] (Table 4). Studies have shown a good acceptability of upright active desks in children [49][51][44], with a willingness to use it in the future and a reduction of sleepiness [43]. From teachers' perspective, they have declared a positive influence of upright active desks to complete tasks and are willing to continue teaching with upright active desks [45]. One study reported that parents have felt a positive impact on their children's behavior at school [41]. However, one study [38] reported some negative effects with the use of upright active desks such as a slight deterioration of the relation with classmates. Authors also reported, a decrease of the mean duration and habit to use upright active desks over time. Most of those observations were reported in primary schools; secondary schools observed an improvement of the attitude towards the desk [38].

For cycling desks, authors [30] observed no change in attention and task completion compared to traditional desks. Students also experimented a reduction of fidgeting. Their preference to sit on cycling desks compared to traditional desks was higher despite the lack of a comfortable seat. Overall, cycling desks have been perceived by teachers and students as a positive tool to improve the environment of school class.

It was determined by the review team that a meta-analysis was not possible due to high levels of heterogeneity across studies; narrative syntheses were employed instead. The overall quality of the included studies was low due to methodological inconsistencies, in addition of the heterogeneity in terms of statistical and clinical characteristics ([Table 2](#) and [Table 3](#)).

Table 2. Study risks of bias.

dies	Random Sequence Generation	Allocation Concealment	Performance Bias	Detection Bias	Attrition Bias	Reporting Bias	Other Bias
Upright active desk							
Benden et al. (2011) ^[40]	Low risk	Unclear	High risk	High risk	Low risk	Low risk	Unclear
Benden et al. (2012) ^[41]	High risk	High risk	High risk	High risk	High risk	Low risk	Unclear
Benden et al. (2014) ^[42]	Low risk	Unclear	High risk	High risk	Low risk	Low risk	Low risk
Blake et al. (2012) ^[43]	High risk	High risk	High risk	High risk	High risk	High risk	Unclear
Clemes et al. (2016) (Bradford, England) ^[31]	High risk	Unclear	High risk	High risk	Low risk	Low risk	Unclear
Clemes et al. (2016) (Melbourne, Australia) ^[31]	Unclear	Unclear	High risk	High risk	Low risk	Low risk	Unclear
Clemes et al. (2020) ^[44]	Low risk	Low risk	High risk	High risk	Low risk	Low risk	Low risk
Dornhecker et al. (2015) ^[45]	Low risk	Unclear	High risk	High risk	Low risk	Low risk	Unclear
Ee et al. (2018) ^[32]	N/A	N/A	High risk	High risk	Low risk	Low risk	Low risk
Kidokoro et al. (2019) ^[46]	High risk	High risk	High risk	High risk	Low risk	Low risk	Low risk
Koepp et al. (2012) ^[47]	High risk	High risk	High risk	High risk	Low risk	Low risk	Unclear
Mehta et al. (2015) ^[48]	High risk	High risk	High risk	High risk	Low risk	Low risk	Low risk
Parry et al. (2019) ^[49]	N/A	N/A	High risk	High risk	Low risk	Low risk	Unclear
Pickens et al. (2016) ^[50]	High risk	Unclear	High risk	High risk	Low risk	Low risk	Unclear
Sherry et al. (2020) ^[51]	High risk	High risk	High risk	High risk	Low risk	Low risk	Low risk
Sprengeler et al. (2020) ^[52]	N/A	N/A	High risk	High risk	Low risk	Low risk	Low risk
Sudholz et al. (2016) ^[53]	High risk	High risk	High risk	High risk	Low risk	Low risk	Low risk
Swartz et al. (2019) ^[54]	N/A	N/A	High risk	High risk	Low risk	Low risk	Low risk
Verloigne et al. (2018) ^[55]	Low risk	Unclear	High risk	High risk	High risk	Low risk	Low risk
Wendel et al. (2016) ^[56]	Low risk	Low risk	High risk	High risk	Low risk	Low risk	Low risk
Wick et al. (2018) ^[57]	High risk	Unclear	High risk	High risk	Low risk	Low risk	Low risk

dies	Random Sequence Generation	Allocation Concealment	Performance Bias	Detection Bias	Attrition Bias	Reporting Bias	Other Bias
Cycling desk							
Fedewa et al. (2017) ^[30]	Low risk	Unclear	High risk	High risk	Low risk	Low risk	Unclear
Ruiter et al. (2019) ^[58]	Low risk	Low risk	High risk	High risk	Low risk	Low risk	Unclear
Torbeyns et al. (2017) ^[34]	Low risk	Unclear	High risk	High risk	Low risk	Low risk	Low risk
Stability ball							
Erwin et al. (2016) ^[33]	Low risk	Unclear	High risk	High risk	Low risk	Low risk	Unclear
Fedewa et al. (2015) ^[59]	Low risk	High risk	High risk	High risk	Low risk	Low risk	Unclear

N/A: not applicable; Other bias included any potential conflict of interest in studies.

Table 3. Association between the use of active desks and outcomes of included studies for the systematic review.

[illegible]

Outcome Assessment	No of Studies	Design	Quality Assessment					Quality	
			Risk of Bias	Inconsistency	Indirectness	Imprecision	Other		
	3	RCT ^q	No serious risk of bias	No serious inconsistency	No serious indirectness	Serious risk of imprecision ^r	None		MODERATE
	6	NRCT ^s	Serious risk of bias ^t	No serious inconsistency	No serious indirectness	Serious risk of imprecision ^u	None		VERY LOW
	1	RT ^v	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None		LOW
	4	Cross-over ^w	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None		LOW
Energy expenditure	School grade ranged between 1 and 10. Energy expenditure was assessed by a portable device (armband) during school days and/or entire days.								
	4	RCT ^x	No serious risk of bias	No serious inconsistency	No serious indirectness	Serious risk of imprecision ^y	None		MODERATE
	1	NRCT ^z	Serious risk of bias ^{aa}	No serious inconsistency	No serious indirectness	Serious risk of imprecision ^{ab}	None		VERY LOW
	1	NRT ^{ac}	Serious risk of bias ^{ad}	No serious inconsistency	No serious indirectness	Serious risk of imprecision ^{ae}	None		VERY LOW
Cognitive and academic performance	School grade ranged between 2 and 10. Cognitive performance was assessed by cognitive functions test (working memory, inhibitory control, flexibility, attention) and on-task behaviors (observations, interviews)								
	4	RCT ^{af}	Serious risk of bias ^{ag}	No serious inconsistency	No serious indirectness	No serious imprecision	None		MODERATE
	4	NRCT ^{ah}	Serious risk of bias ^{ai}	No serious inconsistency	No serious indirectness	No serious imprecision	None		VERY LOW
	3	NRT ^{aj}	Serious risk of bias ^{ak}	No serious inconsistency	No serious indirectness	No serious imprecision	None		VERY LOW
Fatigue and musculoskeletal symptoms	School grade ranged between 4 and 10. Fatigue and musculoskeletal symptoms were assessed by questionnaires (Nordic Musculoskeletal Questionnaire, paper questionnaires), teacher observations, focus groups and/or interviews.								
	1	RCT ^{al}	No serious risk of bias	No serious inconsistency	No serious indirectness	Serious imprecision ^{am}	None		MODERATE
	2	NRCT ^{an}	Serious risk of bias ^{ao}	No serious inconsistency	No serious indirectness	Serious imprecision ^{ap}	None		VERY LOW
	1	NRT ^{aq}	Serious risk of bias ^{ar}	No serious inconsistency	No serious indirectness	No serious imprecision	None		VERY LOW

Outcome Assessment	No of Studies	Design	Quality Assessment					Quality
			Risk of Bias	Inconsistency	Indirectness	Imprecision	Other	
	2	Cross-over ^{as}	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	LOW
Process evaluation	Mean age ranged between 6 and 17 year. Perceptions and experiences of participants was assessed by questionnaires, self-reporting answers and/or interviews.							
	3	RCT ^{at}	Serious risk of bias ^{au}	Serious inconsistency ^{av}	No serious indirectness	No serious imprecision	None	LOW
	4	NRCT ^{aw}	Serious risk of bias ^{ax}	No serious inconsistency	No serious indirectness	No serious imprecision	None	VERY LOW
Physical capacities and cardiometabolic health	School grade ranged between 4 and 10. Physical capacities was assessed by the 20 m shuttle run test. Cardiometabolic health was assessed by blood pressure.							
	2	RCT ^{ay}	No serious risk of bias	No serious inconsistency	No serious indirectness	Serious imprecision ^{az}	None	MODERATE

5. Conclusions

Active desks appear as a promising tool to reduce sedentary behaviors in school environment. In the present state of knowledge, the effects of all active desks appear not equivalent, mainly due to the difference in body activation and energy expenditure. Regarding the relatively low number of available studies and the high degree of heterogeneity in terms of quality, design and methods, comparisons and conclusions remain difficult at the moment. The present systematic analysis calls for further well-designed studies to better understand the effects of the use of active desks among children and adolescents in order to inform policy and practice.

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