Reducing sedentary behaviour and improving spinal health in South African primary school children: findings of a pragmatic stepped-wedge feasibility randomized controlled trial

Dominic Fisher, Rentia Maart, Lehana Thabane, Quinette Louw

Submitted to: JMIR Formative Research
on: August 07, 2024

Table of Contents

Reducing sedentary behaviour and improving spinal health in South African primary school children: findings of a pragmatic stepped-wedge feasibility randomized controlled trial

Dominic Fisher[1] PhD; Rentia Maart[2] PhD; Lehana Thabane[3] PhD; Quinette Louw[2] PhD

[1]StellenboschUniversity Cape Town ZA
[2]Stellenbosch University Cape Town ZA
[3]McMaster University Hamilton CA

Corresponding Author:
Dominic Fisher PhD
StellenboschUniversity
Francie van Zijl Avenue
Cape Town
ZA

Abstract

Background: Non-communicable diseases resulting from sedentary behaviour (SB) are adding further strain on the South African health system, which is already struggling to manage infectious diseases. Some countries have enabled children to reduce SB at school by substituting traditional furniture with sit-stand classroom furniture. Alternating between sitting and standing benefits spinal health, but no such intervention exists in South Africa. It is therefore essential to consider several contextual factors, such as the acceptability of the intervention, its impact on teachers' practices, and the logistical and pragmatic considerations of data collection. This study therefore aimed to assess the feasibility of implementing a classroom-based intervention to reduce SB and improve spinal health in primary school learners.

Objective: The study objectives were to assess the pragmatics of delivering and adherence to a classroom-based intervention and assess the pragmatics of measuring physical activity and postural dynamism data with activPAL and Noraxon Myomotion inertial measurement units (IMUs), respectively.

Methods: We used a stratified, closed-cohort, randomised, two-cluster, stepped-wedge design with a pragmatic approach. One grade 5 and 6 class each were recruited from contrasting socio-economically categorised, publicly funded primary schools in the Western Cape Province, South Africa. Classroom furniture was substituted with sit-stand desks and health and movement videos were shown during class time. Skin-mounted activPAL physical activity monitors and Noraxon Myomotion Inertial measurement units were used to measure SB and spinal movement respectively. The study was evaluated for feasibility by tracking school retention, successful delivery of the videos and use of the desks, compliance with the wearable sensors, and data accuracy. We deductively analysed teacher interviews and learners' focus groups using Atlas.ti 9 software. Descriptive analysis of quantitative data was done using Microsoft Excel.

Results: All feasibility outcomes were met in cluster two. Cluster one withdrew from the study before follow-up SB, postural topography and spinal movements were measured. The study found that it is feasible to conduct a larger trial with minor modifications to the methodology.

Conclusions: We recommend a whole-school approach to support the intervention and a monitoring strategy to track the impact of the intervention on the classroom. Furthermore, we recommend contextualised teacher training on how sit-stand desks and health education videos can be utilised as classroom management tools. Clinical Trial: Pan African Trials Registry PACTR201811799476016; Registered 22 November 2018 – retrospectively registered; https://tinyurl.com/y4upoys8

(JMIR Preprints 07/08/2024:65169)
DOI: https://doi.org/10.2196/preprints.65169

Preprint Settings

1) Would you like to publish your submitted manuscript as preprint?

✔ **Please make my preprint PDF available to anyone at any time (recommended).**
Please make my preprint PDF available only to logged-in users; I understand that my title and abstract will remain visible to all users.
Only make the preprint title and abstract visible.
No, I do not wish to publish my submitted manuscript as a preprint.

2) If accepted for publication in a JMIR journal, would you like the PDF to be visible to the public?

✔ **Yes, please make my accepted manuscript PDF available to anyone at any time (Recommended).**
Yes, but please make my accepted manuscript PDF available only to logged-in users; I understand that the title and abstract will remain v
Yes, but only make the title and abstract visible (see Important note, above). I understand that if I later pay to participate in <a href="http

Original Manuscript

Reducing sedentary behaviour and improving spinal health in South African primary school children: findings of a pragmatic stepped-wedge feasibility randomized controlled trial

Dominic Fisher, PhD[1,2], Rentia Maart PhD[2], Lehana Thabane PhD[2,3] , Quinette Louw PhD[2]

[1] School of Health Professions, Faculty of Health, University of Plymouth

[2] Division of Physiotherapy, Department of Health and Rehabilitation Sciences, Faculty of Medicine and Health Sciences, Stellenbosch University, Cape Town, South Africa

[3]Department of Health Research Methods, Evidence, and Impact (formerly the Department of Clinical Epidemiology and Biostatistics), McMaster University, Hamilton, ON, Canada

Corresponding author:

Dominic Fisher

School of Health Professions, Faculty of Health, University of Plymouth

InterCity Place, Plymouth Railway Station, North Road East, Plymouth, PL4 6AB

Phone: +441752587580

Email: dominic.fisher@plymouth.ac.uk

ABSTRACT

Background: Non-communicable diseases resulting from sedentary behaviour (SB) are adding further strain on the South African health system, which is already struggling to manage infectious diseases. Some countries have enabled children to reduce SB at school by substituting traditional furniture with sit-stand classroom furniture. Alternating between sitting and standing benefits spinal health, but no such intervention exists in South Africa. It is therefore essential to consider several contextual factors, such as the acceptability of the intervention, its impact on teachers' practices, and the logistical and pragmatic considerations of data collection. This study therefore aimed to assess the feasibility of implementing a classroom-based intervention to reduce SB and improve spinal health in primary school learners.

Methods: We used a stratified, closed-cohort, randomised, two-cluster, stepped-wedge design with a pragmatic approach. One grade 5 and 6 class each were recruited from contrasting socio-economically categorised, publicly funded primary schools in the Western Cape Province, South Africa. Classroom furniture was substituted with sit-stand desks and health and movement videos were shown during class time. Skin-mounted activPAL physical activity monitors and Noraxon Myomotion Inertial measurement units were used to measure SB and spinal movement respectively. The study was evaluated for feasibility by tracking school retention, successful delivery of the videos and use of the desks, compliance with the wearable sensors, and data accuracy. We deductively analysed teacher interviews and learners' focus groups using Atlas.ti 9 software. Descriptive analysis of quantitative data was done using Microsoft Excel.

Results: All feasibility outcomes were met in cluster two. Cluster one withdrew from the study before follow-up SB, postural topography and spinal movements were measured. The study found that it is feasible to conduct a larger trial with minor modifications to the methodology.

Conclusions: We recommend a whole-school approach to support the intervention and a monitoring strategy to track the impact of the intervention on the classroom. Furthermore, we recommend contextualised teacher training on how sit-stand desks and health education videos can be utilised as classroom management tools.

Trial registration: Pan African Trials Registry PACTR201811799476016; Registered 22 November 2018 – retrospectively registered; https://tinyurl.com/y4upoys8

Funding: This project is funded by the National Research Foundation (CPRR150720128324).

KEY MESSAGES REGARDING FEASIBILITY

- This study addressed the uncertainty of the acceptability of a classroom-based SB and spinal health intervention, its impact on teachers' practice and the logistical and pragmatic considerations of data collection in a previously unresearched setting.
- Feasibility outcomes success criteria regarding the delivery of health education videos, participants' compliance with wearable sensors and the integrity of the data collected were met in both clusters.
- Cluster retention in a future trial may be supported by a whole school approach to implementing the intervention. A monitoring strategy to track its impact on the classroom is recommended.
- Teacher training about SB and utilising sit-stand classroom furniture and health education videos as classroom management tools is also recommended.

INTRODUCTION

The prevalence of preventable, long-term, non-communicable diseases (NCDs) presents a serious strain on the South African healthcare system, already under pressure from the burden of infectious disease management (1). While the causes of NCDs are multifactorial, there is consensus that lifestyle, including sedentary behaviour (SB), is a major contributor (2). Any waking behaviour with energy expenditure less than or equal to 1.5 metabolic equivalent units while sitting, lying down or reclining is considered sedentary (1). While initial SB interventions were mainly focused on adults, the understanding that SB in adulthood tracks through from childhood and adolescence (3) expanded SB research to include younger populations. Interventions aimed at reducing SB in children have shown promise, with several studies demonstrating good efficacy in reducing SB by educating parents, teachers, and children about the harmful effects of SB (4). Interventions to address SB initially focussed on substituting discretionary screen time with periods of physical activity. However, understanding that the beneficial effects of physical activity, even at the prescribed WHO dose, do not undo the detrimental physiological effects of SB (5), has led to the development of interventions to prevent the accumulation of SB.

School-based SB studies have demonstrated high levels of accumulated periods of non-discretionary sedentary time during class (6). These high levels of SB are attributable to teachers' preference that children remain seated during class (7), and environmental barriers to interrupting SB when teachers encourage the movement (8). The conventional classroom environment is not conducive to increasing children's movement without compromising teaching and learning. As a result, classroom-based SB interventions trialled dynamic, sit-stand furniture to overcome the environmental barriers posed by traditional classroom furniture.

Interrupting prolonged sitting bouts by alternating between sitting and standing may have the additional benefit of improving spinal health. Prolonged sitting has been shown to increase axial loading of the spine and increase back muscle activation which could lead to back pain (9). Given that spinal pain tracks to adulthood from childhood (7, 10) and the reported high levels of non-discretionary, classroom sedentary time, alternating children's postural topography may have dual long-term benefits on children's cardiometabolic and spinal health. It is proposed that alternating between sitting and standing (alternating postural topography) mitigates the effects of prolonged loading in one position by providing periods of relative rest. This approach aligns with the theory of postural dynamism which encourages regular spinal movement as opposed to maintaining a single preferred spinal position. Altering postural topography may promote spinal health by mitigating axial load on spinal posture and encouraging regular spinal movement. The dual benefit of interrupting prolonged sitting and encouraging transitioning between sitting and standing during class holds significant public health potential in resource-limited contexts such as South Africa.

Classroom-based interventions comprising dynamic, sit-stand furniture, health education and movement integration that have been conducted in the United States of America, Europe, Australia, and New Zealand, have shown good efficacy in reducing SB without disturbing teaching and learning activities (4). To our knowledge, no such studies have been conducted in South Africa. Conducting a trial of a classroom-based intervention in South Africa would have to consider a range of contextual factors related to the educational system, socio-economic inequality, not to mention the logistic and pragmatic considerations. Before implementing such a trial, it is important to establish the contextual viability of a previously untested intervention. Given the likely increase in children's movement in response to a classroom-based intervention and the potential impact on teacher practice, it was considered to determine the acceptability of the intervention (11, 12). In addition, a pragmatic methodology to measure postural topography, physical activity and spinal movement needed to be established before being implemented in a large trial. Furthermore, the integrity of data collected in a new environment needed to be assessed. These are all key aspects needed to establish the feasibility of conducting a large trial to assess the beneficial effects of a novel SB intervention in a South African classroom context.

The aim of this study was thus to assess the feasibility of implementing a classroom-based intervention to reduce classroom SB and promote spinal health in primary school learners. The study objectives were to assess the pragmatics of delivering and adherence to a classroom-based intervention and assess the pragmatics of measuring physical activity and postural dynamism data with activPAL and Noraxon Myomotion inertial measurement units (IMUs), respectively. This manuscript will focus only on the primary, feasibility outcomes. The preliminary findings of the effects will be published subsequently.

METHODS

This study report follows the Consolidated Standards of Reporting Trials (CONSORT) extension statement for pilot and feasibility trials (13). The protocol for this feasibility trial has been published elsewhere (14). This study was granted ethical approval by the Stellenbosch University Health Research Ethics Committee (reference number: S17/08/130) and institutional permission by the Western Cape Education Department (reference number: 20170525-1279). It was also registered with the Pan African Trials Registry PACTR201811799476016; https://tinyurl.com/y4upoys8

International Registered Report Identifier (IRRID): RR1-10.2196/18522.

Study design

A school-based, stratified, closed cohort, randomized, two-cluster stepped wedge design with a pragmatic approach was used for this study. Participant clusters (school classrooms) were the unit of randomization to determine the order of implementing the intervention. The CONSORT stepped-wedge flow diagram (Figure 1) for cluster randomized trials (15) shows the timing of crossover from control to intervention conditions.

	Randomized transition from usual classroom conditions to intervention condition					
Cluster	Week 1 - 2 23 April 2018 – 10 May 2018	Week 3 11 - 16 May 2018	Week 4 - 5 23 April 2018 - 10 May 2018	Week 6 - 14 14 May 2018 – 10 August 2018	Week 15 - 16 13 – 24 August 2018	31 July - 15 August 2019
Cluster 1 Quintile 5 classroom	Usual conditions	Baseline measurement & introduce intervention	Intervention	Intervention	Withdrawal from study & qualitative interviews	Usual conditions - withdrawn from study
Cluster 2 Quintile 3 classroom	Usual conditions	Usual conditions	Baseline measurement & introduce intervention	Intervention	Follow up measurement & qualitative interviews	Follow up measurement & qualitative interviews

Time →

Figure 1 CONSORT stepped-wedge design diagram

The stepped-wedge design was used to allow the intervention to be evaluated within the bounds of the logistical constraints and context of each cluster (16). Furthermore, given the evidence of the effectiveness of the mode of intervention in other contexts (4), and other classroom-based interventions, the stepped-wedged design allowed both clusters to receive the potential benefit of the intervention.

Study setting

The study was conducted in the Western Cape province of South Africa, a region of broad language, cultural and socioeconomic diversity. In South Africa, publicly funded (state schools) are categorized into quintiles according to socio-economic factors including income, literacy, and employment rates of the surrounding community (17). Lower quintile schools are more resource-limited than upper quintile schools and thus receive greater state funding per registered learner. In the metro central district, there are fewer lower quintile schools, and most schools fall under the quintile five category.

Sampling and recruitment

To ensure a diverse range of contextual factors, primary schools from quintiles 3 and 5 were selected exclusively from the central metro district of the Western Cape Education Department. The rationale was that if it were deemed to be feasible to conduct a future trial in the more challenging, resource-strained context, it would be feasible in less challenging, adequately resourced contexts. A downloaded list of publicly funded schools in the central metro district from the Western Cape Education Department website was delimited to school quintile categories three (Q3) and five (Q5). School principals, stratified according to Q3 and Q5 schools, were randomly contacted by the principal investigator via telephone or email for recruitment. Afterwards, the principals nominated grade 5 or 6 teachers to attend an information session. Those who expressed interest in participating were provided with consent forms for their participation, child assent, parent/guardian consent forms, and study information for parents and guardians, which were then collected by the research team upon completion. Before the study began, learners were informed about the intervention and measurement methods.

Sample size

A sample size calculation was not performed as per the CONSORT extension statement for feasibility studies (18). The sample target was to include a wide range of contextual factors relevant to the feasibility outcomes. The diversity between the clusters (namely, classrooms from Q3 and Q5 schools) was considered sufficient to provide a range of considerations to assess the feasibility of the intervention and the pragmatics of data collection. The individual participants selected for measuring physiological outcomes (SB and postural dynamism) were randomly chosen from the class list provided by the class teacher. An equal number of male and female learners were sampled.

Intervention

The study intervention comprised a novel height-adjustable sit-stand desk and a playlist of nine HEMVs. The study authors (DF, QL) contributed to the development of the intervention. The design concept was informed in part by a systematic review of the efficacy of classroom-based interventions to improve spinal health and reduce the sedentary behaviour of school children (4) as well as a qualitative study of educators' perceptions of learners' movement during class time conducted in the Western Cape, South Africa (7). The systematic review provided compelling evidence for the efficacy of classroom-based interventions that include alternative, sit-stand classroom furniture and health education to improve spinal health and sedentary behaviour outcomes.

Sit-stand desk

The research team considered the sit-stand desks available in South Africa prohibitively expensive and thus unsuitable for implementation in the study. An innovation team developed a novel, multi-functional, height-adjustable, sit-stand classroom desk, called the KUZE (Supplementary file 1) for this study. Learners and teachers were shown how to select the correct height for sitting and standing. All the usual classroom chairs were removed and replaced with KUZE sit-stand desks during the study period.

Health education and movement videos (HEMVs)

The innovation team comprising the authors, professional video content creators and a teacher who advocates for using body movement in teaching mathematics developed a series of HEMVs for this study. Learners were instructed to follow the videos which included an interactive component, requiring them to solve simple arithmetic problems using corresponding body movements (Supplementary file 2). The teachers were handed the HEMVs on a mobile external hard drive and after discussions with the researchers, were given the freedom to develop their own strategies for playing the videos during class time. The videos are available to view on YouTube (14).

Control conditions

The control conditions were the usual classroom conditions. The cluster 1 and cluster 2 classrooms had similar dimensions. The cluster 1 classroom furniture was metal framed, wooden, all-in-one, tandem desks that fit two learners abreast (Supplementary file 3). The cluster 2 classroom furniture had a combination of single and double metal framed, wooden tables with accompanying plastic moulded chairs (Supplementary file 3). The HEMVs were not played during control conditions. The health education programme was conducted in both cluster classrooms during the control period.

Pragmatics of physiological data collection using wearable sensors

Physical activity monitoring - activPAL

Participants' classroom physical activity and postural topography (sitting, standing, stepping and sit-to-stand transitioning) were measured using activPAL3 microsensors. The use of activPAL sensors have been widely used to objectively measure physical activity in the last decade (19-21). Sensors were applied to participants before the start of lessons and removed after the end of lessons on physiological data collection days. The sensors were attached to the anterior right thigh with a waterproof nitrile sleeve and Opsite dressing as prescribed by the user manual. Data logged on the sensors were downloaded into a secure file at the end of each day.

Spinal movement - Noraxon Myomotion Inertial Measurement Units (IMUs)

Postural dynamism was measured using Noraxon Myomotion IMUs. Wearable IMUs allow for the assessment of postural dynamism in an ecologically valid setting of the classroom. The IMUs combine on-board triaxial gyroscopes, accelerometers, and magnetometers for accurate sensor orientation tracking (22). IMUs were attached to the head (with an elasticated Velcro belt) and to the neck, thorax, and sacrum directly to the skin using double-sided tape.

Description and measurement of feasibility outcomes

The feasibility outcomes include retention of the study, fidelity to the intervention (acceptance, and usage of the KUZE sit-stand desks, delivery of the health education videos) and the integrity of physiological data collected (compliance with wearing the activPAL and IMU sensors and the integrity of the data collected). The success indicators (set a priori) and methods of measuring the five feasibility outcomes are outlined in Table 1.

Table 1 Feasibility outcomes, success indicators and measurement methods

	Feasibility outcome	Success indicator	Measurement method
1	Cluster retention	Both clusters remain in the study until follow-up measurements obtained.	Retention rate recorded on project management record. Qualitative feedback from teachers regarding retention.
2	Delivery of HEMVs	Teacher develops a routine of playing the videos and adhered to the routine	Qualitative feedback from teachers and learners at exit interview.
3	Acceptance and usage of the KUZE desk in the classroom	Learners and teachers accept and use KUZE as classroom furniture for entire study period	Retention rate recorded on project management record. Qualitative feedback from teachers and learners regarding acceptance of

			KUZE.
4	Compliance with wearing activPAL and IMU sensors	100% compliance with wearing activPAL sensors and IMUs for the duration of the intended measurement period	Recorded on project management record.
5	Integrity of physical activity and postural dynamism data	80% of all data captured activPAL and sensors and IMUs eligible for inclusion in the analysis	Recorded on project management record.

The feasibility outcomes were measured using both qualitative and quantitative methods. For the qualitative measurement of the feasibility outcomes, individual depth interviews (IDIs) with the class teachers and focus group discussions (FGDs) with a subgroup of learner participants from each cluster were conducted at the end of the intervention period. The success criteria of the feasibility outcomes were used as the framework for the IDIs and FGDs. The quantitative methods encompassed the physiological data obtained from the activPAL and IMU sensors as well as estimates of retention and compliance which were monitored by the researcher.

Interpretation of feasibility criteria

The success criteria set a priori were:

1. Continue with a large pilot/trial feasible if all five success criteria are met in both clusters; or

2. Make minor modifications to the protocol if three or more criteria are met in both clusters before continuing with a pilot/trial; or

3. Make significant protocol modifications if two or less criteria are met in both clusters (18).

DATA ANALYSIS

Qualitative analysis

A deductive analysis of data from individual teacher interviews and focus group discussions with learners was conducted to determine the feasibility outcomes and success indicators. The qualitative feedback sessions were recorded and transcribed in full, and then analyzed using Atlas.ti 9*, a Computer Assisted Qualitative Data Analysis Software. Atlas.ti 9* facilitates the organization, coding, analysis, and visualization of data (23). Learner and teacher responses were grouped into corresponding themes related to classroom retention, intervention delivery, acceptance, and usage of the KUZE. At the end of the intervention, two focus group discussions per cluster were conducted. The focus group comprised both individuals who provided physiological data and those who were only exposed to the intervention but did not provide physiological data. Verbatim representative quotes of participant responses are provided.

Quantitative analysis

Categorical data were analysed descriptively and presented as percentages. The number of participant classes (clusters) that remained in the study for the duration of the study was documented and presented as a percentage of the total participant classes that enrolled in the study. The proportion of data used in the analysis compared to data collected is presented as a percentage. All analyses were performed using Microsoft Excel.

RESULTS

The CONSORT flow diagram of the study is illustrated in Figure 5.

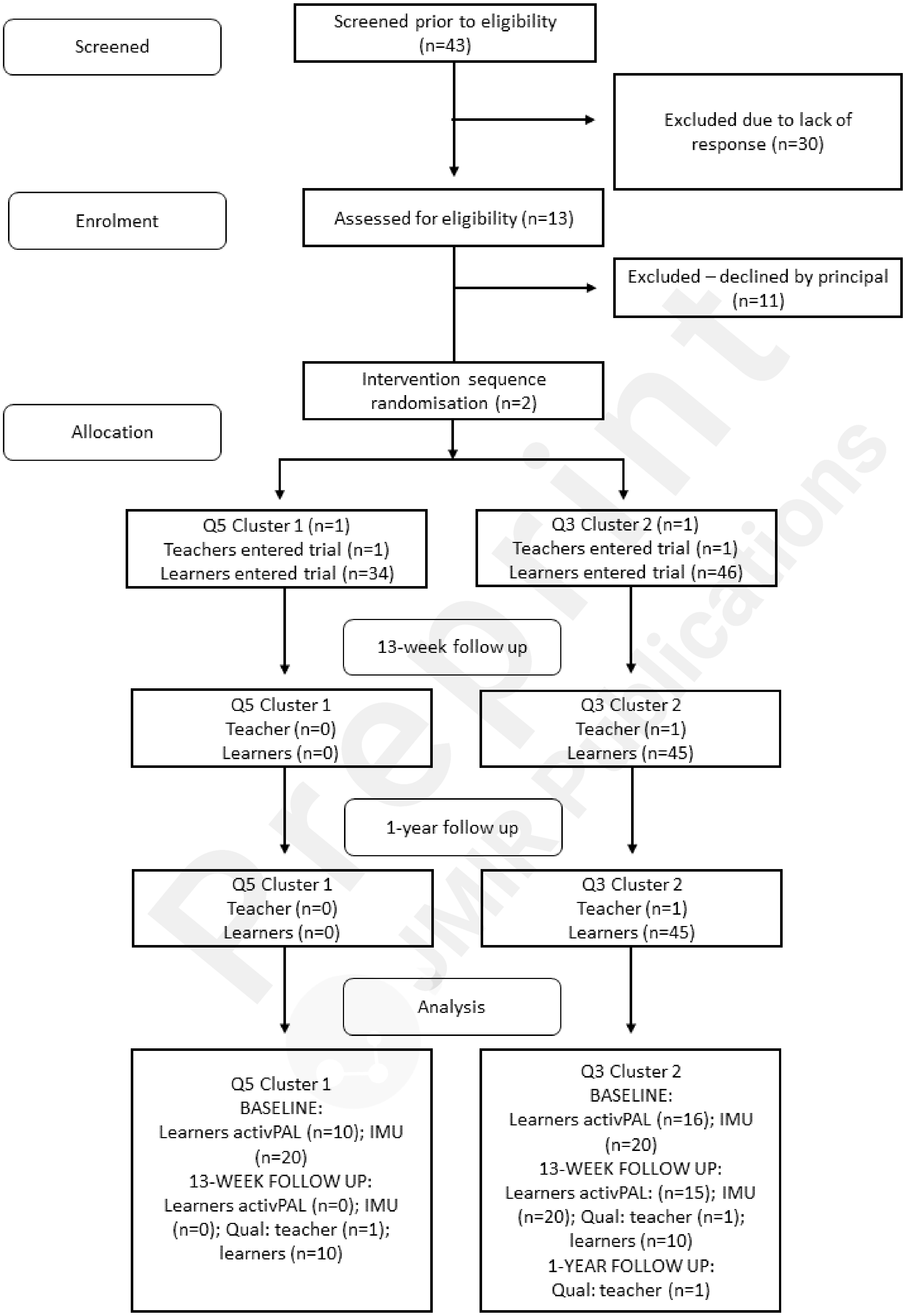

Figure 2 CONSORT flow diagram of feasibility trial

Demographic characteristics

The baseline demographic characteristics of participants were similar across clusters. The cluster 1 (Q5) school comprised a grade 6 class, while cluster 2 (Q3) was a grade 5 class. Thus, the ages of the learners in this study were 10-11 years old. An equal number of male and female learners made up the study sample.

Feasibility outcome 1: cluster retention

The cluster 1 (Q5) teacher withdrew her consent to participate in the study after the 13-week intervention and before physiological follow-up measurements were taken. However, the teacher and learners participated in the individual depth interview and focus group discussions respectively. Cluster 2 (Q3) remained in the study throughout the study period. Table 2 demonstrates at which stage the one cluster withdrew.

Table 2: Components of retention for clusters 1 and 2

Cluster	Recruitment	Baseline measurements	Intervention	Follow-up measurement	Qualitative interviews
Cluster 1	ü	ü	ü	✘	ü
Cluster 2	ü	ü	ü	ü	ü

Qualitative findings

Based on the qualitative findings, the reasons for withdrawal from the study were analysed into three themes, namely, the way access to the classroom was negotiated; the teacher’s preference for not being video recorded during data collection; and the perceived disruption to teaching and learning by the study.

Access negotiation

The same strategy was used to recruit both clusters. Negotiation of access to the classroom was done via the school principal and the original teacher (cluster 1). However, a last-minute substitute teacher was employed immediately before the commencement of the study. The school principal discussed the project and its requirements with the substitute teacher. However, the substitute teacher felt that she was not adequately informed of the full extent of the study, despite receiving the study information material.

So I didn't really know. So I was like, okay, I'll wait for you (the researcher) to come, maybe you'll tell me and then suddenly it was a whole setup in my class, and I was like, what is going on? (Teacher, cluster 1)

The teacher in cluster 2 was satisfied with the recruitment strategy.

Yes. It was the right way. Starting with the principal of course...the principal would never decide on her own. She had to go to the teachers and bring this to the teachers and hear what they say. (Teacher, cluster 2)

Preference for not being video recorded

The cluster 1 teacher was uncomfortable about being recorded on video. She reported that she was self-conscious about being on camera, which influenced her interactions with the learners. The teacher in cluster 2 did not have objections to the use of video for postural dynamism data collection.

Well I mean, having someone basically watching you [laughing]. You don't really have freedom with your kids because you say something, but you get recorded on video. (Teacher, cluster 1)

Perception of disruption to teaching and learning

The cluster 1 teacher felt that the intervention (KUZE) interfered with her preferred way of arranging the classroom furniture.

And I found that, because the way my class is set out, I put my class when it was rows, so, before I had groups but then when the desk came I only could have rows because that was the only thing that could fit in my class. (Teacher, cluster 1)

To standardize the orientation of learners for postural dynamism measurement, learners were required to sit facing the front of the classroom. The teacher reported that learners often had to be moved from their usual desk and this impacted interpersonal dynamics with the person next to them.

Maybe that, but also, as you know my class, I had groups. So you needed your kids to face the front. So that also caused moving around and disruptions, like this child don't want to sit next to that child, but yet they had to because … to accommodate the project. (Teacher, cluster 1)

The teacher was concerned that disruptions to teaching and learning would impact learners' academic performance and decided it was best to withdraw from the study.

I don't think my kids can afford to have all that interruptions especially during the second term when we have exams and the third term when we have systemics. So I needed to be focused all the time. So having the disruption was just a lot to manage. (Teacher, cluster 1)

Feasibility outcome 2: delivery of HEMVs

Both teachers reported having developed a routine for playing the health education videos during class. The cluster 1 teacher played the HEMVs intermittently during the day, while the cluster 2 teacher utilized the videos as a classroom management tool to his advantage. He played the videos at the start of the periods to engage learners and prepare them for the lesson.

So what I did is the morning I played them one, in the beginning of the day and before first break. Then second break I don't have them, so … They go for two hours they go somewhere else [to a different classroom] and then maybe a video at the end of the day. (Teacher, cluster 1)

Because of the start of the period, I want them to bring their minds before doing maths… it's like an exercise where everybody would feel right for the lesson…We didn't do that a lot every day. Most of the time I did the videos when it's my first period in my class. (Teacher, cluster 2)

Feasibility outcome 3: acceptance and usage of the KUZE desk in the classroom

Teachers and learners in both clusters accepted the KUZE as the classroom furniture for the duration of the intervention period. The cluster 1 teacher allowed learners to stand during groupwork activities for specific subjects and during times where independent work was required.

I think the desk was helpful in that situation, yes, where they had their own work to do without *having extra work on the board or looking at the board. So when they had independent tasks like that then I think it was okay to be standing, but also not for a long period of time because they tend to move around and they're free to walk around. (Teacher, cluster 1)*

I think it was actually amazing for me not to be sitting... Just sitting there like a stick insect the whole time and sometimes you can't even concentrate in class because your head is down. But you're active from those desks you brought us [KUZE]. (Learner, cluster 1)

Learners in cluster 2 were allowed to use their discretion whether to sit or stand while completing their work and to break up periods of sitting. At the end of the intervention period, the KUZE desks were removed from cluster 1 and the usual classroom furniture was returned. The cluster 2 teacher requested that the KUZE remain as the standard classroom furniture in his class beyond the completion of the study. When asked about whether they wanted to return to using their usual classroom furniture, learners from cluster 2 chose to keep the KUZE furniture.

I think I was going to use it for the new learners maybe next year. Because as I can see now the other classes they see these desks. Now they are also curious ... (Teacher, cluster 2)

I want you to keep the cosi [KUZE] chairs for us... and our teacher said the cosi [KUZE] chairs are good for us so that we can stand. (Learner, cluster 2)

The teacher in cluster 2 reported that the KUZE desks provided a valuable advantage of more space to access all the areas of the classroom.

The advantage they [KUZE desks] give me is that in that classroom there is space, it's spacious, you see. I can now move in between them... I am able to move around, looking at their books. (Teacher, cluster 2)

Feasibility outcome 4: compliance with wearing activPAL and IMU sensors

There was 100% compliance with wearing activPAL sensors and IMUs. No learners reported any adverse skin reactions to wearing the activPAL sensors at any stage of the study. During the 13-week follow-up measurement, ten participants reported mild head discomfort from the elasticated Velcro strap used to secure the head IMU. In all cases, the discomfort was resolved by readjusting the strap. Thereafter, the learners were able to return to class and resume learning activities. The mild discomfort that learners reported from the head strap had resolved before they were allowed to return to the class to complete the period of data collection. All learners selected for physiological measurements complied with wearing the activPAL sensors and IMUs throughout the study.

Feasibility outcomes 5: integrity of physical activity and postural dynamism data

A low rate of data loss was recorded for physical activity and postural dynamism (Table 3). An average of 94.64% of recorded SB and spinal movement data had sound integrity and was considered eligible for inclusion in the analysis for the secondary objectives. The rate of data integrity met the a priori target of 80%. Data loss from wearable sensors was attributable to technical problems during downloading to the project computer or due to batteries running out of charge.

Table 3 Percentage of data from objective measurements

	Cluster 1		Cluster 2	
Measurement period	activPAL data integrity (%)	IMU data integrity (%)	activPAL data integrity (%)	IMU data integrity (%)
Baseline	87,23	92,86	98,48	100
13-weeks	withdrew	withdrew	98,48	95
1-yr follow up	withdrew	withdrew	83,75	not measured

Summary of feasibility outcomes

Three of the feasibility outcomes were achieved in three criteria in both clusters. As cluster 1 was not retained in the study, the acceptance and usage of the KUZE could only be assessed partially through qualitative feedback, thus categorised as ‘partially met’. All five feasibility outcomes were achieved in cluster 2 (Table 4).

Table 4 Results of success criteria

Feasibility outcomes	Success indicator	Outcome	
		Cluster 1	Cluster 2
Classroom retention	Both clusters remain in the study until follow-up measurements obtained.	Unmet	Met

Delivery of HEMVs	Teacher develops a routine of playing the videos and adhered to the routine	Met	Met
Acceptance and usage of the KUZE desk in the classroom	Learners and teachers accept and use KUZE as classroom furniture for entire study period	Partially met	Met
Compliance with wearing activPAL and IMU sensors	100% compliance with wearing activPAL sensors and IMUs for the duration of the intended measurement period	Met	Met
Integrity of physical activity and postural dynamism data	80% of all data captured activPAL and sensors and IMUs eligible for inclusion in the analysis	Met	Met

DISCUSSION

This study found that, based on the criteria for this study, it is likely feasible to conduct a larger trial of a classroom-based intervention to reduce classroom sedentary behaviour and improve spinal health. The findings show that the a priori success criteria to decide to continue with a large trial were met. Having met three feasibility outcome success criteria (delivery of HEMVs, compliance with wearing physical activity and postural dynamism sensors, and the integrity of the data gathered) in both clusters indicates that with minor modifications to the study methodology, it is feasible to progress to a larger trial. Despite this positive finding, reduced cluster retention may be a risk of a larger trial. Therefore, strategies to enhance retention is an important consideration for a larger trial.

Individual teacher-related aspect should be considered in retention strategies. The last-minute substitution of the teacher meant that the research team was unable to establish a satisfactory level of engagement, rapport and support before the study started. This may have led to a negative attitude toward the study that was compounded by her perceived loss of autonomy due to the study related changed to the classroom furniture and configuration. Holistic support of teachers is important in classroom-based movement integration interventions (24) to maintain adequate levels of engagement and support throughout the process of the study. Such a holistic ‘whole school approach’ that includes senior school management and other school stakeholders has gathered traction in interventions to increase physical activity in UK primary schools (25). However, such a whole school approach will need to be contextualised for the South African school system considering the scarce track record of implementation of similar interventions. Given the importance of teachers in implementing the study and dynamic nature in school settings, the design of a future trial should incorporate pragmatism to ensure that timely and appropriate adaptation are possible throughout the study. (26).

While not retaining cluster 1 (Q5) was disappointing, it provides a valuable learning opportunity to inform a larger trial. It is therefore recommended that a customised school-context-specific programme of engagement, awareness and involvement in the study precede a future trial to improve participants’ experience of participation (27) and to optimise its acceptability and efficacy (28). Prior teacher involvement and programme monitoring may also provide the opportunity to co-develop cluster retention strategies for implementation in a future trial, aid the development, implementation and adaptation of the intervention and track cluster progress against study goals (29). These are important considerations for a future trial given the sizeable investment requirement in an emerging area of research in South Africa.

Despite no previous classroom-based interventions including sit-stand desks in South Africa, the KUZE desk was well accepted by teachers and learners. Teachers recognised the positive impact of allowing learners to stand on their ability to work independently and on their concentration after prolonged periods of sitting. However, some concerns were raised about disruption to teaching and learning and loss of control of the classroom, which presents a potential threat to the roll out of a future trial. Similar concerns were voiced by teachers in a previous UK based trial (11). These concerns are reasonable given the longstanding tradition and practice of enforcing learners to remain seated during class time. Interrupting periods of sitting with standing tasks challenges teachers' practice and propensity to enforce sitting during teaching and learning activities. In a study of teachers' perspectives of learners' movement during class, participants reported that they believed that sitting enhances learners' concentration (7) and were unaware of the evidence that interrupting prolonged sitting may enhance their concentration and engagement with cognitive tasks (30, 31). Teachers in the study by Fisher and Louw (2023) associated enforcing that learners remain seated with teachers' maintaining control of the classroom and their level of classroom management skill and teaching pedagogy. It may be prudent to emphasise the benefits of interrupting prolonged sitting for learners in future teacher training and support as part of a future trial of the intervention.

The activPAL sensor wear protocol used in this study did not appear to impact the logistics or integrity of the physical activity data collected. The decision to apply and remove the activPAL sensors daily was mainly motivated by not wanting to risk losing the expensive devises. The research team also considered the ethics of the potential safety risks study participants would bear by wearing expensive devices in their communities without any mitigating measures in place. Most studies of free-living physical activity using activPAL adopt a 24-hour, 7-day wear protocol (32). However, this wear protocol has drawn some criticism with evidence of a dose response non-compliance with wear protocols approaching the 7-day period (33). Reports of skin irritation caused by perspiration, particularly in warm, humid conditions have threatened study participants' compliance with wearing the sensors (34). The fact that no skin irritation was reported by study participants justifies the rationale for the wear protocol. If this activPAL wear protocol was adopted in a future study, it may be useful to determine the validity of the single wear protocol compared to 24-hour, 7-day wear protocol.

Conclusions and recommendations

Having established the feasibility of some aspects of the intervention in the local context, the acceptance of the sit-stand desks remains questionable and presents a potential risk to the success of a larger trial. Although teachers and learners from both clusters accepted and used the intervention classroom furniture for the duration of the intervention period, the feedback from the cluster 1 teacher raises some uncertainty. However, these concerns can be addressed as described in the recommendations below. The results of this study indicate that minor revisions to the current methodology are required to conduct a large cluster randomized controlled trial of an intervention aimed at reducing SB and improving spinal health in primary schools in the Western Cape.

Recommended changes to the methodology include:

- A holistic whole school approach to the intervention including all grade teachers and school management to support implementation of intervention, particularly playing health education videos
- A monitoring strategy to track the impact of the intervention on the classroom, teacher and school's environment as well as the ability to adapt and implement pragmatic strategies to enhance retention
- Contextualized teacher training on how sit-stand desks and health education videos can be utilized as a classroom management tool

Study limitations

The study was limited to schools in a specific geographical and socio-economic context. Therefore, the findings may not be generalisable. The interpretation of some findings was limited by the sub-optimal retention of one cluster. The study was also limited to specific pre-set feasibility criteria and important implementation factors e.g., teacher and school dynamics were not considered. The feasibility study's data is also arguably too limited for sample size considerations for a larger trial and further research is required.

Declarations

Ethics approval

This study was granted ethical approval by the Stellenbosch University Health Research Ethics Committee (reference number: S17/08/130) and institutional permission by the Western Cape Education Department (reference number: 20170525-1279).

Consent for publication

Not applicable.

Availability of data and material

The datasets during and/ or analysed during the current study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

This project is funded by the National Research Foundation (CPRR150720128324).

Authors' contributions

DF was the major contributor to drafting and writing the manuscript. Conceptualization, DF and QAL; Methodology, DF and QAL and LT; Validation, QAL, LT, RAM; Formal Analysis, DF and QAL; Investigation, DF and QAL; Data Curation, DF and QAL; Writing—Original Draft Preparation, DF; Writing—Review and Editing, QAL, LT, RAM; Visualization, DF and QAL; Funding Acquisition, QAL. All authors have read and agreed to the published version of the manuscript.

Acknowledgements

The authors thank the innovation team, Jaco Langenhoven, Kurt Minnaar, Sjan-Mari van Niekerk, and D'ave Meyer for contributing to the study.

References

1. Tremblay MS, Aubert S, Barnes JD, Saunders TJ, Carson V, Latimer-Cheung AE, et al. Sedentary Behavior Research Network (SBRN) - Terminology Consensus Project process and outcome. Int J Behav Nutr Phys Act. 2017;14(1):75.
2. Poses-Ferrer E, Parisi R, Gonzalez-Viana A, Castell C, Arias de la Torre J, Jones A, et al. Daily sitting time and its association with non-communicable diseases and multimorbidity in Catalonia. Eur J Public Health. 2022;32(1):105-11.
3. Biddle SJ, Pearson N, Ross GM, Braithwaite R. Tracking of sedentary behaviours of young people: a systematic review. Prev Med. 2010;51(5):345-51.
4. Fisher D, Louw Q. The Effect of Classroom-Based Interventions on Sedentary Behavior and Spinal Health in Schoolchildren: Systematic Review. Interact J Med Res. 2022;11(2):e39006.
5. Ryan DJ, Stebbings GK, Onambele GL. The emergence of sedentary behaviour physiology and its effects on the cardiometabolic profile in young and older adults. Age (Dordr). 2015;37(5):89.
6. Ridgers ND, Salmon J, Ridley K, O'Connell E, Arundell L, Timperio A. Agreement between activPAL and ActiGraph for assessing children's sedentary time. Int J Behav Nutr Phys Act. 2012;9:15.
7. Fisher D, Louw Q. Primary school learners' movement during class time: perceptions of educators in the Western Cape, South Africa. BMC Public Health. 2023;23(1):2501.
8. Gibson CA, Smith BK, Dubose KD, Greene JL, Bailey BW, Williams SL, et al. Physical activity across the curriculum: year one process evaluation results. Int J Behav Nutr Phys Act. 2008;5:36.
9. O'Sullivan K, O'Sullivan P, O'Keeffe M, O'Sullivan L, Dankaerts W. The effect of dynamic sitting on trunk muscle activation: a systematic review. Appl Ergon. 2013;44(4):628-35.

10. Hoy D, Brooks P, Blyth F, Buchbinder R. The Epidemiology of low back pain. Best Pract Res Clin Rheumatol. 2010;24(6):769-81.
11. Clemes SA, Bingham DD, Pearson N, Chen YL, Edwardson CL, McEachan RRC, et al. Stand Out in Class: restructuring the classroom environment to reduce sitting time - findings from a pilot cluster randomised controlled trial. Int J Behav Nutr Phys Act. 2020;17(1):55.
12. Hinckson EA, Aminian S, Ikeda E, Stewart T, Oliver M, Duncan S, et al. Acceptability of standing workstations in elementary schools: a pilot study. Prev Med. 2013;56(1):82-5.
13. Campbell MK, Piaggio G, Elbourne DR, Altman DG, Group C. Consort 2010 statement: extension to cluster randomised trials. BMJ. 2012;345:e5661.
14. Fisher D, Louw Q, Thabane L. Sedentariness and Back Health in Western Cape Primary School Students: Protocol for a Pragmatic Stepped-Wedge Feasibility Randomized Controlled Trial. JMIR Res Protoc. 2020;9(11):e18522.
15. Hemming K, Taljaard M, Grimshaw J. Introducing the new CONSORT extension for stepped-wedge cluster randomised trials. Trials. 2019;20(1):68.
16. Copas AJ, Lewis JJ, Thompson JA, Davey C, Baio G, Hargreaves JR. Designing a stepped wedge trial: three main designs, carry-over effects and randomisation approaches. Trials. 2015;16:352.
17. van Dyk H, White CJ. Theory and practice of the quintile ranking of schools in South Africa: A financial management perspective. South African Journal of Education. 2019;39(Supplement 1):S1-S9.
18. Eldridge SM, Chan CL, Campbell MJ, Bond CM, Hopewell S, Thabane L, et al. CONSORT 2010 statement: extension to randomised pilot and feasibility trials. Pilot Feasibility Stud. 2016;2:64.
19. Ridley K, Ridgers ND, Salmon J. Criterion validity of the activPALTM and ActiGraph for assessing children’s sitting and standing time in a school classroom setting. International Journal of Behavioral Nutrition and Physical Activity. 2016;13(1).
20. Contardo Ayala AM, Salmon J, Timperio A, Sudholz B, Ridgers ND, Sethi P, et al. Impact of an 8-Month Trial Using Height-Adjustable Desks on Children's Classroom Sitting Patterns and Markers of Cardio-Metabolic and Musculoskeletal Health. Int J Environ Res Public Health. 2016;13(12).
21. Sherry AP, Pearson N, Ridgers ND, Johnson W, Barber SE, Bingham DD, et al. Impacts of a Standing Desk Intervention within an English Primary School Classroom: A Pilot Controlled Trial. Int J Environ Res Public Health. 2020;17(19).
22. Balasubramania S, editor COMPARISON OF ANGLE MEASUREMENTS BETWEEN VICON AND MYOMOTION SYSTEMS2013.
23. Friese S. Qualitative data analysis with ATLAS.ti. Third edition. ed. xxxiii, 307 pages p.
24. Routen AC, Johnston JP, Glazebrook C, Sherar LB. Teacher perceptions on the delivery and implementation of movement integration strategies: The CLASS PAL (Physically Active Learning) Programme. International Journal of Educational Research. 2018;88:48-59.
25. Jones G, Longbon K, Williams S. Exploring the acceptability and feasibility of a whole school approach to physical activity in UK primary schools: a qualitative approach. BMC Public Health. 2022;22(1):2236.
26. Pearson M, Chilton R, Wyatt K, Abraham C, Ford T, Woods HB, et al. Implementing health promotion programmes in schools: a realist systematic review of research and experience in the United Kingdom. Implement Sci. 2015;10:149.
27. Wilson P, Mathie E, Keenan J, McNeilly E, Goodman C, Howe A, et al. ReseArch with Patient and Public invOlvement: a RealisT evaluation – the RAPPORT study. Health Services and Delivery Research. 2015;3(38).
28. Sanders EBN, Stappers PJ. Probes, toolkits and prototypes: three approaches to making in codesigning. CoDesign. 2014;10(1):5-14.

29. Schultz L, Ruel-Bergeron J. Considerations for Monitoring School Health and Nutrition Programs. Front Public Health. 2021;9:645711.
30. Tobia V, Sacchi S, Cerina V, Manca S, Fornara F. The influence of classroom seating arrangement on children's cognitive processes in primary school: the role of individual variables. Curr Psychol. 2022;41(9):6522-33.
31. Wannarka RaR, K. Seating Arrangements that promote positive academic and behavioural outcomes: a review of empirical research. Support for Learning. 2008;23(2):89-93.
32. Edwardson CL, Winkler EAH, Bodicoat DH, Yates T, Davies MJ, Dunstan DW, et al. Considerations when using the activPAL monitor in field-based research with adult populations. J Sport Health Sci. 2017;6(2):162-78.
33. Shi Y, Huang WY, Yu JJ, Sheridan S, Sit CH-P, Wong SH-S. Compliance and Practical Utility of Continuous Wearing of activPAL™ in Adolescents. Pediatric Exercise Science. 2019;31(3):363-9.
34. Maddocks M, Byrne A, Johnson CD, Wilson RH, Fearon KC, Wilcock A. Physical activity level as an outcome measure for use in cancer cachexia trials: a feasibility study. Support Care Cancer. 2010;18(12):1539-44.

Supplementary Files

Untitled.

Untitled.

Untitled.


let's
START TO
MOVE
5
let's
Do our
3
TIMES TABLE!
good
Posture
=
moving
AROUND
DiD you
KNOW
sitting isn't
good?

CONSORT (or other) checklists

CONSORT-extension_Feasibility of SB and Spinal Health.
URL: http://asset.jmir.pub/assets/661805061056d437626c4a9a4928b0d0.pdf