Effects of the inclusion of physical activity in secondary education academic classes on educational indicators and health markers: Rationale and methods of the ACTIVE CLASS study

María González-Pérez
GALENO Research Group, Department of Physical Education, Faculty of Education Sciences, University of Cadiz, Puerto Real, Spain
David Sánchez-Oliva (davidsanchez@unex.es)
ACAFYDE research group, Department of Didactics of Musical, Plastic and Body Expression, Faculty of Sports Sciences, University of Extremadura, Cáceres, Spain
Alberto Grao-Cruces
GALENO Research Group, Department of Physical Education, Faculty of Education Sciences, University of Cadiz, Puerto Real, Spain
Enrique Cano-Cañada
ACAFYDE research group, Department of Didactics of Musical, Plastic and Body Expression, Faculty of Sports Sciences, University of Extremadura, Cáceres, Spain
Fátima Martín-Acosta
GALENO Research Group, Department of Physical Education, Faculty of Education Sciences, University of Cadiz, Puerto Real, Spain
Raúl Muñoz-González
ACAFYDE research group, Department of Didactics of Musical, Plastic and Body Expression, Faculty of Sports Sciences, University of Extremadura, Cáceres, Spain
Francisco J. Bandera-Campos
GALENO Research Group, Department of Physical Education, Faculty of Education Sciences, University of Cadiz, Puerto Real, Spain
Abel Ruiz-Hermosa
University of Castilla-La Mancha, Social and Health Care Research Center, Cuenca, Spain
Miguel Vaquero-Solís
ACAFYDE research group, Department of Didactics of Musical, Plastic and Body Expression, Faculty of Sports Sciences, University of Extremadura, Cáceres, Spain
Carmen Padilla-Moledo
GALENO Research Group, Department of Physical Education, Faculty of Education Sciences, University of Cadiz, Puerto Real, Spain
Julio Conde-Caveda

GALENO Research Group, Department of Physical Education, Faculty of Education Sciences, University of Cadiz, Puerto Real, Spain

Víctor Segura-Jiménez

UGC Medicina Física y Rehabilitación, Hospital de Neurotraumatología y Rehabilitación, Hospital Universitario Virgen de las Nieves, Granada, Spain

Inmaculada González-Ponce

ACAFYDE research group, Department of Didactics of Musical, Plastic and Body Expression, Faculty of Sports Sciences, University of Extremadura, Cáceres, Spain

Tomás García-Calvo

ACAFYDE research group, Department of Didactics of Musical, Plastic and Body Expression, Faculty of Sports Sciences, University of Extremadura, Cáceres, Spain

José Castro-Piñero

GALENO Research Group, Department of Physical Education, Faculty of Education Sciences, University of Cadiz, Puerto Real, Spain

Daniel Camiletti-Moirón

GALENO Research Group, Department of Physical Education, Faculty of Education Sciences, University of Cadiz, Puerto Real, Spain

---

Research Article

Keywords: Physically active learning, Active breaks, Adolescents, Physical fitness, Sedentary time, Academic indicators, Cognition, Motivational variables

Posted Date: September 15th, 2023

DOI: https://doi.org/10.21203/rs.3.rs-3199782/v1

Additional Declarations: No competing interests reported.

Abstract

Background: Physical inactivity and sedentary levels among children and adolescents are significant concerns. The school setting presents an ideal scenario for implementing strategies aimed at improving physical activity (PA) levels and reducing sedentary behaviours. However, most of the interventions have primarily focused on children, and limited evidence is available for adolescents. This paper presents the design, measurements, and interventions implemented in the ACTIVE CLASS study, which aim to assess the effects of two interventions on PA levels, sedentary time, health-related physical fitness academic indicators, cognition, and markers of psychological health among secondary education students.

Methods: A randomized controlled study is conducted with a total of 292 students from six schools (7^{th} and 8^{th} grade) in Spain (three in Cadiz and three in Caceres). One school from each study region is randomly assigned to either the active break intervention group, the physically active learning intervention group, or the control group. The interventions have a duration of 16 weeks. Nine main measurement categories are assessed: PA and sedentary time, health-related physical fitness, academic indicators, cognition, psychological health, motivational variables, dietary patterns, sociodemographic characteristics, and qualitative information. Three temporal moments of evaluation are distinguished: pre-intervention, post-intervention (week 16) and retention measurement (four weeks after the intervention). Qualitative information is assessed solely during the post-intervention measurement.

Discussion: To the best of our knowledge, the ACTIVE CLASS study is the first of its kind in Spain to evaluate the effects of incorporating active breaks and physically active learning in secondary education. Moreover, this project will offer valuable and innovative training to the educational community, enabling them to implement teaching methodologies that have the potential to enhance academic performance and improve the quality of life for their students.

Trial registration: NCT05891054 (clinicaltrials.gov), 06/06/2023.

Background

Physical activity (PA) has been consistently associated with physical (i.e., adiposity, cardiometabolic health, health-related physical fitness (HRPF), bone health, etc.) [1]. In addition to its positive impact on physical health, physical activity (PA) has consistently been associated with psychosocial health (i.e., well-being, self-image, anxiety, depression, satisfaction with life, happiness, etc.) in children and adolescents [2]. Consequently, the World Health Organization (WHO) recommends that children and adolescents aged 5 to 17 should accumulate at least 60 minutes of moderate-to-vigorous PA (MVPA) per day [3]. However, there is a concerning scenario in Europe, where the majority of adolescents, exceeding 71%, fail to meet these PA guidelines [4]. This lack of adherence to PA guidelines has significant implications for the development of non-communicable diseases.

Schools serve as environments where millions of children and adolescents, representing diverse socioeconomic backgrounds, cultures, and fitness profiles, coexist for extended periods of time. This

makes the school an ideal setting for developing strategies to encourage the adoption of healthy lifestyle habits. Moreover, the American Heart Association recommends that children and adolescents should accumulate at least 30 minutes of MVPA in the school day [5]. Nevertheless, a recent systematic review revealed that less than a quarter of children and adolescents worldwide meet these recommendations for physical activity during school hours [6]. On average, children and adolescents accumulate only 3 to 22% and 2 to 8% of their school time in MVPA, respectively [6]. Moreover, sedentary behaviours are prevalent during the school day, with children and adolescents spending a significant amount of time sitting at their desks [7, 8]. The increased use of screens for activities such as simple projectors further exacerbate this sedentary situation.

Thus, the Sedentary Behaviour Research Network (SBRN) recommends replacing screen-based learning activities with screen-free activities, preferably incorporating movement [9]. Currently, schools serve as alarming hubs of inactivity and sedentary behaviour, necessitating strategies that aim to increase moderate-to-vigorous physical activity (MVPA) levels and reduce prolonged sedentary periods during the school day. Traditionally, physical education lessons and recess have been regarded as opportune periods to incorporate PA during the school day. However, such methods have proven ineffective in increasing PA levels, particularly among adolescents [10]. As a result, there has been a growing interest in recent years in developing strategies to enhance PA levels during subjects traditionally taught in a static manner within the classroom, such as mathematics, geography, and history. Two such strategies are active breaks (AB) and physically active learning (PAL)[11, 12].

AB involve incorporating short breaks of PA (usually with moderate or vigorous intensity) into academic lessons, excluding physical education [13]. Research suggests that implementing AB of varying durations (ranging from 5–15 minutes) appears to be associated with improvements in PA levels [14–17] and educational outcomes, such as time-on-task [14, 16, 17]. However, the findings regarding to academic performance and cognitive performance have been mixed [16, 17]. In addition, it is important to note that most of the evidence on active breaks comes from studies conducted in primary education, and there is limited research on the effectiveness of this type of intervention in secondary education. Few studies that have evaluated the effectiveness of AB in secondary education have reported conflicting results regarding to the impact on time-on-task [18, 19], as well as promising results on cognitive variables such as attention, concentration and mathematical calculation [20].

PAL involves integrating physical activity into lessons in key learning areas other than physical education (e.g. mathematics) [13]. Previous studies have suggested positive effects of PAL on PA levels, time-on-task and academic performance in primary education children [21]. However, there is no clear evidence regarding changes in HRPF as a result of PAL, with some studies reporting significant effects [22, 23] while others do not [21]. Likewise, as in AB, the effects of this type of intervention on cognitive markers are inconclusive [21]. The existing evidence in secondary education is again discordant, where PAL appears to be associated with improvements in school-based PA levels, but not in total PA [24], as well as contradictory results on the effect of PAL on academic performance [25, 26]. Furthermore, there is a need

for studies in this population that include other variables known to have a positive association with PA, such as time on task [27] and cognitive variables [28].

The scarcity of studies and the disparity of results found in secondary education, joined with the observed decline in PA levels during this stage [29, 30], underscore the importance of implementing interventions in the classroom. Moreover, if we focus on the Spanish context, to date no such interventions have been carried out in the secondary education classroom.

Thus, this study reports on the methods and rationale of the ACTIVE CLASS study. This randomized controlled trial (RCT) examines the effect of two active learning intervention (AB and PAL) on PA levels, sedentary time, educational indicators, cognition, and markers of physical and psychological health in secondary education students.

Methods/design

Study Design

The ACTIVE CLASS study is a RCT (trial registered in Clinicaltrials.gov: NCT05891054), with randomization at school level. An intervention is developed in two experimental groups (AB intervention and PAL intervention), with pre- and post-intervention measures. Additionally, a follow-up measure is conducted four weeks after the intervention to assess the sustainability of the intervention programme.

ACTIVE CLASS is a multicentre study whose management is designed to ensure effective collaboration and communication between research groups. The research groups consist of qualified researches and graduates in PA and sport sciences from two Universities [University of Cadiz (UCA) and University of Extremadura (UEX), Spain]. Both Research groups adhere to a common study protocol for training, fieldwork, data collection and management, and quality control procedures. There is continuous telematic contact during the development of the study. In addition, each research group has responsible investigators who manage the day-to-day running of the study in their centres and are in continuous contact with their counterparts at the other university to make decisions on aspects that require a quick response or do not require a meeting of all the in researchers.

Participants and selection criteria

Participants in the ACTIVE CLASS study are apparently healthy adolescents from secondary schools in the regions of Cadiz and Caceres (Spain). The ACTIVE CLASS study establishes the following inclusion criteria:

- *Participants' selection criteria for adolescents' students*: (i) studying 7th or 8th grade (12–14 years old); (ii) not having a physical disability or health problem that could limit PA levels.
- *Schools´ selection criteria*: (i) having a minimum of 60 students in 7th and 8th grade; (ii) not participating in any other PA or health promotion programme; (iii) Be located within a radius of 15

kilometres of the research group's work centres in Cadiz and Caceres.

Figure 1 illustrates the flow diagram of the participants recruitment process. A total of 20 schools in Caceres and 64 schools in Cadiz are invited to participate through a letter of invitation addressed to the school's management. A meeting is held with the management teams of the schools that accept the invitation, to explain the study and obtain their consent. From the total number of schools which accept to participate and provide their consent (three schools, both in Cadiz and Caceres), a randomization process at school level is conducted in each study region. Thus, three study groups are established in each city (Cadiz and Caceres): (i) AB intervention group, (ii) PAL intervention group, and (iii) control group. All students in the 7th or 8th grade of the participating schools who give their informed consent are invited to participate in the study. The parents of the students receive an information document describing the study, the inclusion criteria, the informed consent process, and an invitation to attend an information meeting at the school. To participate in the study, the parents or guardians must sign the informed consent form, along with the student's consent.

A total of 292 participants were included in the study, ensuring effect sizes of 0.1 with an alpha level of 0.05 and a power of 0.80, even with an experimental dropout rate of 25% (GPower 3.1.9.4, Düsseldorf, Germany).

Interventions

The ACTIVE CLASS study implements two intervention programmes over a period of 16-weeks:(i) AB, and (ii) PAL, consisting of including PA in academic lessons for secondary education, while a third group serves as a control.

Active break intervention:

Active break intervention takes place daily and is carried out in the normal academic lessons, where two ABs per day are included in the 7th and 8th grade timetable of each secondary school. The timing of the active breaks is coordinated with the school management team. Whenever possible, one AB is scheduled before recess and the other after recess. It is important to note that no active breaks are scheduled during physical education classes or the lesson immediately following physical education. This ensures that the effect of the active breaks is not solely attributed to the physical activity performed in the preceding physical education class. The remaining class time follows the usual methodology without any variation.

The implementation of this intervention utilizes digital platform accessible to schools through individuals' usernames and passwords. This platform has been specifically designed to facilitate the development of AB in school classes. An example of AB can be found in the following link: https://www.dropbox.com/s/dtye613hb3m3c50/VideoDescansoActivo.mp4?dl=0. This innovative tool allows to programme different types of AB easily and quickly, playing with variables such as physical exercise, its duration or intensity. Based on the findings from the review by Daly-Smith et al. [16], each AB has a duration of 5 minutes, of which 4 minutes of activity are used, including two sets of 20 seconds of

work and 10 seconds of rest of four different exercises. Finally, a cool down consisting of deep breaths is performed. The activities selected for each of the AB include aerobic and strengthening activities (i.e., jumps, squats, lunges or skipping).

Teachers have access to the platform and are responsible for conducting the active breaks as scheduled by the research team. During the active breaks, students follow the instructions provided by an avatar that guides the session through the platform. To ensure the proper use of the platform, the research team provides training and support to the teachers. During the initial phase of the intervention, the research team accompanies the teachers for the first two weeks to ensure a smooth implementation of the active breaks and address any questions or concerns that may arise. This support aims to familiarize the teachers with the platform and ensure they feel confident in delivering the active breaks effectively.

Physically active learning intervention:

PAL intervention involves integrating PA into academic lessons, specifically within the subject of mathematics. This subject has a substantial body of evidence supporting its applicability for physically active learning, as it is a core subject taught in all grades of secondary education. Out of the total number of mathematics lessons taught per week in Spanish schools (four one-hour classes per week), one class per week for 16 weeks is dedicated to the PAL intervention. Each of the PAL is developed outside the classroom during the intervention.

The mathematics teacher corresponding to this intervention group, previously trained and with the constant support of the research team, oversees implementing the strategies in their academic lessons. Before each PAL class, the research team and the mathematics teacher collaborate in a meeting to determine the specific content to be covered and co-develop the activities to be included in the session. Some examples of activities used in the sessions can be found in the following free downloadable book: https://www.dykinson.com/libros/aprendizaje-fisicamente-activo-fundamentos-teoricos-y-estrategias-practicas-para-la-materia-de-matematicas-en-1o-y-2o-de-eso/9788411701617/.

Control group:

The control group receives the usual academic lessons during the 16-weeks of intervention, without methodological modification or inclusion of breaks that could alter the usual levels of PA during school hours.

Measures

Participants are assessed at baseline (January 2023), post-intervention (May 2023), and one month after the intervention (June 2023) to test the stability over time of the strategies offered to teachers. To minimize variability in assessments, all measurements are conducted in schools by trained researchers who have received prior training.

Primary outcome measures

Physical activity and sedentary time:

Actigraph (Actigraph GT3X+, Inc., Pensacola, FL, USA) is used to measure PA and sedentary time. Participants wear the monitor on the non-dominant wrist for eight consecutive days. Participants are instructed to wear the accelerometer throughout the day (including sleeping hours), except for aquatic or situations where the device may come into contact with water. The screening and data collection procedures are conducted following the established protocols used in previous studies involving adolescents [31].

Secondary outcome measures

Health-related physical fitness:

Those tests comprising the High Priority ALPHA Health-Related Fitness Test Battery [32] are used to assess HRPF:

20-m shuttle run test is used to assess cardiorespiratory fitness. Two lines are marked on the track 20-m apart. Participants run back and forth between the lines, following a straight trajectory and matching the rhythm of an audio recording. The initial speed is 8.5 km/h and is increased by 0.5 km/h per leg (each leg corresponds to one minute). The test ends when the participant stops due to fatigue or when he does not cross the lines marked to the pace of the acoustic signals on two consecutive occasions. The test is performed once, and the last stage or half stage completed by the participant is scored.

Hand grip test is used to assess upper body maximal isometric muscular fitness. A validated hand-held dynamometer with an adjustable grip (TKK 5101 Grip D; Takey, Tokyo, Japan) is used. Prior to the test, the dynamometer´s grip is adjusted to the size of the participant's hand [33]. During the test, the participants stand upright and hold the dynamometer in one hand. They progressively squeeze the dynamometer until maximum force is developed, maintaining the pressure for at least two seconds, while ensuring that the elbow, arm, and trunk remain stable and unmoving. The test is performed twice, alternating between each hand. The maximum score achieved with each hand is recorded in kilograms, and the mean value between the two scores is calculated and saved for further analysis.

Standing broad jump test is used to lower body explosive muscular fitness. The participants stand behind a line with feet shoulder width apart. Then, with a slight swing, the participant is asked to jump forward as far as possible with both feet. If the participants rest his hands or lifts his feet off the ground on landing, the test is invalid. The test is performed twice, and the best score attained is recorded in centimetres for analyses.

Body mass index and waist circumference is used to assess body composition. For body mass measurement, participants stand barefoot on an electronic scale (type SECA 861; range, 0.05 to 130 kg; accuracy, 0.05 kg). Height measurement is taken in the Frankfort plane using a telescopic height measuring instrument (type SECA 225; range, 60 to 200 cm; accuracy, 1 mm). Each measurement is taken

twice, and the mean of the two measurements is recorded. Body mass index is calculated as weight/height squared (kg/m^2). On the other hand, waist circumference is measured using a non-elastic tape (SECA 200; range, 0 to 150 cm; accuracy, 1 mm). The tape is placed in the frontal plane at the midpoint between the superior iliac spine and the costal border at the mid-axillary line. The measurement is taken twice, and the mean of the two measurements is recorded.

Additionally, subjective PF is measured through the International Fitness Scale (IFIS) [34]. This scale is based on responses to five FP questions: overall FP, cardiorespiratory fitness, muscle fitness, speed-agility, and flexibility. Participants are asked to rate each of the FP components on a 5-point Likert-type scale ranging from: "very poor" (1); "poor" (2); "acceptable" (3); "good" (4) and "very good.".

Academic indicators:

School engagement: The engagement scale (UWES-S-9) [35] is used to evaluate school engagement. The UWES-S-9 is composed of nine items that reflect the three dimensions of engagement: (i) vigor; (ii) absorption; and (iii) dedication, each dimension is represented by three items that are evaluated through a Likert-type scale, ranging from "never" (0 points) to "always" (6 points).

Learning perception: Learning perception in mathematics is assessed by the questionnaire developed by Abella et al [36]. The questionnaire consists of eight items that measure two dimensions: "perceived learning" (items 1–4) and "satisfaction with learning" (items 5–8). Participants rate their agreement with each item on a five-point Likert scale, with "1" indicating "strongly disagree" and "5" indicating "strongly agree".

Academic performance

It is evaluated through the marks reported by the schools in the three official evaluations of the academic year, specifically in January, April and June.

Time-on task: Time-on task is evaluated in mathematics classes or the time at which the AB are to be held and in the consecutive class one hour later. Students' on-task behaviour were graded attending to the guidelines used Mahar et al. [37] in on-task and off-task. On one hand, on-task behaviour is characterized by students making eye contact with the teacher and actively following the teacher's instructions or class rules. On the other hand, off-task behaviour is identified when students fail to pay attention or break class rules. In turn, off-task behaviour is further categorized into three subtypes: (i) off-task-motor (any motor response that breaks the rules and/or disrupts the learning situation); (ii) off-task-noise (any oral response that breaks the classroom rules and/or disrupts the learning situation and (iii) off-task-passive (moments when the student does not participate in any interaction or do anything when expected to participate).

During each assessment, a researcher observes and assess six students. For the AB group, these assessments take place during the class where the active breaks are implemented and in the consecutive class one hour later. For the PAL and control groups, assessments occur during the mathematics class

and the consecutive class one hour later. Each investigator has 15 seconds to observe and identify the type of behaviour exhibited by each student, recording the observations on a worksheet before moving on to the next student. The investigators are positioned in an area that allows for a comprehensive view of the classroom and are aided by a recording track with headphones to facilitate the evaluation process and maintain the assessment order.

Cognition:

The executive functions of inhibition, cognitive flexibility and working memory are evaluated as main indicators of cognitive function. These are measured using the NIH Examiner programme [38] through the (i) Flanker task; (ii) Shifting task and (iii) N-Back protocols, respectively. In addition, mathematical fluency is assessed with a specific test.

Flanker task

It evaluates the response inhibition and cognitive control [39]. In this test, participants direct their attention to a fish located in the centre of a row of five fish displayed on the screen. The fish in the centre has a mark either above or below it. Each trial has a stimulus presentation time of 1000 milliseconds. Participants are instructed to quickly indicate the direction in which the fish in the centre is pointing.

Shifting task

It evaluates cognitive flexibility [38]. In this test, three figures are displayed on the screen, with one figure positioned at the top and one figure in each corner. The figures are presented in different colours. During the test, the word "SHAPE" or the word "COLOR" appears on the screen, accompanied by the computer reading it aloud. The participants have to associate the figure at the top with one of the figures in the corners. In case of hearing the word "COLOR" the participant should select the figure in the corner that has the same colour as the top figure. On the contrary, in case of hearing the word "SHAPE", the participants have to select the corner figure that has the same shape of the upper figure.

N-Back

it evaluates working memory [40]. In this test, a first screen shows a white square located in a certain place, followed by a number that the participants is asked to read aloud. Subsequently, a second screen is shown with a white square that may be in the same or in a different location of the previous square. The participants should remember the location of the previous square.

Mathematical fluency test

Immediately after the end of the N-Back protocol, a mathematical fluency test is carried out by means of test number 6 of the Woodcock protocol [41]. In this test, participants are given a three-minute period to perform as many simple mathematical calculations as possible.

Psychological health:

Health status is measured through the EuroQol five dimensions three levels (EQ-5D-3L) [42]. The EQ-5D-3L questionnaire measures health status across five dimensions: (i) mobility; (ii) self-care; (iii) usual activities; (iv) pain/discomfort and (v) anxiety/depression. Participants are asked to rate their level of difficulty or problems in each dimension using a Likert-type scale with three response options: (i) no problem, (ii) some problems, and (iii) many problems. This questionnaire also includes a visual analog scale (VAS) to assess general health, where the participants assign a score between 0 and 100 on the VAS to indicate their current perception of their overall health.

On the other hand, self-perceived health is measured through the classic self-reported health item [43], where participants have to classify their health among the following options: "excellent" (5); "very good" (4); "good" (3); "fair" (2) and "poor" (1).

Motivational variables:

Novelty Need Satisfaction Scale (NNSS)

it evaluates novelty [44]. Five of the 19 questions that make up the original scale are selected. Participants are asked to rate their agreement with these five statements on a Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree).

The Spanish version of The Sport Satisfaction Instrument (SSI): It evaluates enjoyment and boredom [45] in mathematics and in general studies. This scale consists of eight items measuring intrinsic satisfaction, with two subscales: satisfaction/enjoyment (five items) and boredom (three items). Participants rate their agreement with the items related to fun or boredom on a five-point Likert-type scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

Teachers´ and students´ perception about the suitability and the development of physically active classes and active breaks:

To gather information about the development of the intervention and gain insights into perceptions, barriers, areas for improvement, strengths, training needs, and sustainability, individual interviews and focus groups are conducted with teachers and students [46].

Teachers involved in the PAL sessions (three teachers in Cadiz and three teachers in Caceres), as well as an equivalent sample of teachers in AB group, participate in one-hour semi-structured individual interviews. These interviews provide an opportunity for teachers to share their experiences, thoughts, and suggestions regarding the PAL and AB. In addition, a one-hour focus group is conducted with a sub-sample of six students from each class in both the AB and PAL groups. These focus groups allow students to express their perceptions, experiences, and opinions about the intervention, providing valuable insights into their engagement, enjoyment, and perceived benefits of the PAL and AB.

Confounding variables

Dietary patterns:

Adherence to the Mediterranean diet is assessed using the updated version 2.0 of the KIDMED questionnaire [47]. The KIDMED 2.0. questionnaire consists of 16 questions that participants answer. The questions in the questionnaire have both positive and negative connotations in relation to the Mediterranean diet. Participants receive a score based on the sum of their responses, and the scores are classified into three levels: (i) ≥ 8, optimal Mediterranean diet; (ii) = 4–7, improvement needed to adjust intake to Mediterranean patterns; (iii) ≤ 3, very low diet quality.

Sociodemographic characteristics:

Sociodemographic characteristics, specifically the socioeconomic status of the participants, are collected using the Spanish-adapted version III of The Family Affluence Scale (FAS III) [48]. This scale consists of six questions related to the purchasing level of the participant's family. Each question is scored on a categorical scale, and the sum of the scores from the six items result in an aggregate index ranging from 0 to 13.

Statistical analysis

Data will be presented as mean and standard deviation or median and interquartile range, if applicable, for continuous variables, and frequency and percentage for categorical variables.

As a cross-sectional fashion, descriptive, correlational, regression and differential analyses will be implemented, as well as Structural Equation Modelling. To assess the effects of the two interventions on outcomes, repeated measured analysis will be used with the outcome measures as dependent variables in separate models, the intervention as an independent variable and controlling for potential confounders (i.e., gender). If normality analyses show non-normal distributions, the equivalent non-parametric analyses will be performed. Quantitative analyses will be completed using the SPSS 26 statistical package (IBM, Armonk, NY, USA), establishing a confidence level of 95% ($p < 0.05$).

In addition, qualitative information from the semi-structured interview and focus group will be analysed using NVIVO software [49].

All the analyses will be carried out considering intention to treat, keeping the participants in the group they were originally allocated and taking into consideration the CONSORT guidelines for cluster RCTs [50].

Discussion

This paper describes the protocol for a RCT that aims to test the effects of an intervention programme based on the inclusion of PA, through AB and PAL, in academic classes on PA levels, sedentary time, HRPF, academic indicators, cognition, and psychological health markers in secondary education students.

Regarding AB and PAL methodologies, the few studies carried out at the secondary education do not show conclusive results. Specifically, in the case of AB, the studies published in secondary education

focus on the variables of time on task and cognition, showing different results on the effect of AB on time on task [18, 19], as well as in the improvement of cognitive variables [20]. The discordances in the results attained to date could be driven by methodological aspects. In this sense, although the duration of AB (ranging from 4–10 min) were similar between studies, different duration of interventions (ranging from one [19], five [18] and eight [20] weeks) and frequency of application (ranging from two [18] to four [20] AB per day) were observed.

Regarding to PAL, PA and academic performance predominate as study outcomes in secondary education. The studies show an association of PAL with an improvement in school PA levels [24], but mixed results in the effect of PAL on academic performance [25, 26]. The discrepancies in the findings may be attributed to variations in the methodologies employed, as it seems that those studies that find a positive association of PAL with the variables studied are those that showed a longer intervention period (between two and seven months) [24, 26]. Furthermore, according to Norris et al. [21], the lack of consistency in reporting the dose of PAL interventions (i.e. duration and frequency), further complicates the comparison of results.

Thus, due to physical inactivity and sedentary lifestyles among school-aged youth [6–8], the importance of conducting interventions such as the ACTIVE CLASS study to address this gap and explore the potential impact of AB and PAL is a need. The results are expected to be similar to those already found in primary education, where the implementation of AB and PAL is positively associated with physical and psychological health [22, 23, 53–55], PA levels [16, 17, 21], time-on-task [16, 17, 21] and academic performance [21]. Although the scientific literature published did not obtain significant changes in cognitive markers in children [16, 21, 51], it is a variable with a potential improvement due to the positive association observed between PA levels and cognitive performance in children and adolescents [28].

Strengths and limitations

The present study has diverse strengths that should be mentioned: (i) it addresses a research gap by focusing on interventions in the secondary education setting, which has received less attention compared to pre-school and primary stages. This study will provide valuable insights into the effectiveness of AB and PAL interventions specifically tailored for secondary education students; (ii) the PAL intervention involves a collaborative approach between mathematics teachers and researchers, ensuring a higher level of fidelity and sustainability of the intervention. This co-development process enhances the integration of physical activity into academic lessons and promotes long-term adoption by teachers; (iii) the study design will bring new evidence allowing to control the internal validity of the results. In addition, to corroborate the stability over time of the strategies offered, a follow-up measure of four weeks is incorporated at the end of the intervention.

On the other hand, some limitations should be mentioned: (i) the generalizability of the study results may be limited to the specific school context and characteristics of the participants included in the study (i.e., facilities, teachers, student motivation, etc.); (ii) the fidelity of the interventions may be compromised

once the research team's support is no longer available. Maintaining consistent implementation of AB and PAL interventions in real-world school settings without continuous research team involvement can be challenging.

Conclusions

The ACTIVE CLASS study examines the effectiveness of including PA in secondary education academic lessons through AB and PAL on PA level and sedentary time, HRPF, academic indicators, cognition, psychological health and motivational variables. The implementation of this RCT has the potential to provide useful and innovative training to the educational community for the implementation of educational methodologies and strategies that facilitate higher academic performance and a better quality of life for their students.

Abbreviations

PA
Physical Activity
WHO
World Health Organization
MVPA
Moderate to Vigorous Physical Activity
AB
Active Break
PAL
Physically Active Learning
UCA
University of Cadiz
UEX
University of Extremadura
R&D&I
Research, Development and Innovation
HRPF
Health-related Physical Fitness
IFIS
International Fitness Scale
EQ-5D-5L
EuroQol Five Dimensions Five Levels
NNSS
Novelty Need satisfaction Scale
SSI

Sport Satisfaction Instrument

Declarations

Ethics approval and consent to participate

The study protocols have been reviewed and approved by the Bioethics Committees of the Andalusian Government (Cadiz, Spain), and the Bioethics and Biosafety Committees of the University of Extremadura (UEX) (Caceres, Spain). The study will be explained to the participants before starting, and the volunteers, parents or tutors sign an informed consent.

Consent for publication

Not applicable

Availability of data and materials

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

Competing interests

The authors declare that they have no competing interests.

Funding

This study was supported by the National Plan for Research, Development and Innovation (R&D&I) from the Spanish Ministry of Science, Innovation and Universities (PID2019-104023RA-I00), the Andalusian Plan for R&D&I Regional Ministry of Economy, Knowledge, Enterprise and University of Andalusia (P20_00908), and the Junta de Extremdura & Fondos Feder (IB20126). VS-J was funded by the Instituto de Salud Carlos III through the fellowship CP20/00178, co-funded by the European Social Fund. ARH is postdoctoral researcher funded by the Margarita Salas Fellowship through the University of Castilla-La Mancha (2021-POST20437).

Authors' contributions

DSO, DCM, AGC, CPM, IGP and TGC conceived the study and participated in its design. DSO, DCM, AGC, MGP drafted the manuscript. FMA, ECC, RMG, FBC, ARH, MVS, CPM, JCC, VSJ, IGP, TGC, JCP participated in the study design and critically revised the manuscript. DSO, DCM, AGC, MGP, FMA, ECC, RMG, FBC, ARH, MVS supervised and designed the AB and PAL interventions. All authors read and approved the final manuscript.

Acknowledgements

The authors gratefully acknowledge the participation and collaboration of all schoolchildren, teachers, school leaders and families in this study.

References

1. Poitras VJ, Gray CE, Borghese MM, Valerie Carson J-PC, Janssen I, Peter T, Katzmarzyk RR, Pate. Sarah Connor Gorber MEK, Margaret Sampson and MST. Systematic review of the relationships between objectively measured physical activity and health indicators in school-aged children and youth1. Appl Physiol Nutr Metab. 2016;41:197–239.
2. Rodriguez-Ayllon M, Cadenas-Sánchez C, Estévez-López F, Muñoz NE, Mora-Gonzalez J, Migueles JH, et al. Role of physical activity and sedentary behavior in the mental health of preschoolers, children and adolescents: A systematic review and meta-analysis. Sport Med. 2019;49:1383–410.
3. Bull FC, Al-Ansari SS, Biddle S, Borodulin K, Buman MP, Cardon G, et al. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. Br J Sports Med. 2020;54:1451–62.
4. Steene-johannessen J, Hansen BH, Dalene KE, Kolle E, Northstone K, Møller NC, et al. Variations in accelerometry measured physical activity and sedentary time across Europe – harmonized analyses of 47, 497 children and adolescents. Int J Behav Nutr Phys Act. 2020;17:1–14.
5. Pate RR, O'Neill JR. Summary of the American Heart Association scientific statement: Promoting physical activity in children and youth: A leadership role for schools. J Cardiovasc Nurs. 2008;23:44–9.
6. Grao-Cruces A, Velazquez-Romero MJ, Rodriguez-Rodriguez F. Levels of physical activity during school hours in children and adolescents: A systematic review. Int J Environ Res Public Health. 2020;17.
7. Grao-cruces A, Sánchez-oliva D, Padilla-moledo C, Cabanas-sánchez V, Castro-piñero J, Sánchez-oliva D, et al. Changes in the school and non-school sedentary time in youth: The UP & DOWN longitudinal study. J Sports Sci. 2020;00:1–7.
8. Abbott RA, Straker LM, Mathiassen SE. Patterning of children's sedentary time at and away from school. Obesity. 2013;21:E131–3.
9. Saunders TJ, Rollo S, Kuzik N, Demchenko I, Bélanger S, Brisson-Boivin K, et al. International school-related sedentary behaviour recommendations for children and youth. Int J Behav Nutr Phys Act. 2022;19:1–14.
10. Borde R, Smith JJ, Sutherland R, Nathan N, Lubans DR. Methodological considerations and impact of school-based interventions on objectively measured physical activity in adolescents: a systematic review and meta-analysis. Obes Rev. 2017;18:476–90.
11. Jones M, X ED, Letsinger A, Steele J, Mackintosh KA. A mixed-studies systematic review and meta-analysis of school-based interventions to promote physical activity and/or reduce sedentary time in

children. J Sport Heal Sci. 2019;1.

12. Dyrstad SM, Kvalø SE, Alstveit M, Skage I. Physically active academic lessons: acceptance, barriers and facilitators for implementation. BMC Public Health. 2018;18:1–11.
13. Watson A, Timperio A, Brown H, Best K, Hesketh KD. Effect of classroom-based physical activity interventions on academic and physical activity outcomes: a systematic review and meta-analysis. Int J Behav Nutr Phys Act. 2017;14:1–24.
14. Bailey R, Ries F, Scheuer C. Active Schools in Europe—A Review of Empirical Findings. Sustain. 2023;15:1–22.
15. Carrasco-Uribarren A, Ortega-Martínez A, Amor-Barbosa M, Cadellans-Arróniz A, Cabanillas-Barea S, Bagur-Calafat MC. Improvement of In-School Physical Activity with Active School-Based Interventions to Interrupt Prolonged Sitting: A Systematic Review and Meta-Analysis. Int J Environ Res Public Health. 2023;20.
16. Daly-Smith AJ, Zwolinsky S, McKenna J, Tomporowski PD, Defeyter MA, Manley A. Systematic review of acute physically active learning and classroom movement breaks on children's physical activity, cognition, academic performance and classroom behaviour: Understanding critical design features. BMJ Open Sport Exerc Med. 2018;4:1–16.
17. Masini A, Marini S, Gori D, Leoni E, Rochira A, Dallolio L. Evaluation of school-based interventions of active breaks in primary schools: a systematic review and meta-analysis. J Sci Med Sport. 2019. https://doi.org/10.1016/j.jsams.2019.10.008.
18. Mavilidi MF, Mason C, Leahy AA, Kennedy SG, Eather N, Hillman CH, et al. Effect of a Time-Efficient Physical Activity Intervention on Senior School Students' On-Task Behaviour and Subjective Vitality: the 'Burn 2 Learn' Cluster Randomised Controlled Trial. Educ Psychol Rev. 2021;33:299–323.
19. Kubesch S, Walk L, Spitzer M, Kammer T, Lainburg A, Heim R, et al. A 30-Minute physical education program improves students' executive attention. Mind Brain Educ. 2009;3:235–42.
20. Ruiz-Ariza A, Suárez-Manzano S, Mezcua-Hidalgo A, Martínez-López EJ. Effect of an 8-week programme of active breaks between classes on cognitive variables in secondary school. https://doi.org/101080/0305569820222128992. 2022;:1–19.
21. Norris E, Van Steen T, Direito A, Stamatakis E. Physically active lessons in schools and their impact on physical activity, educational, health and cognition outcomes: A systematic review and meta-analysis. Br J Sports Med. 2020;54:826–38.
22. de Greeff JW, Hartman E, Mullender-Wijnsma MJ, Bosker RJ, Doolaard SVC. Long-term effects of physically active academic lessons on physical fitness and executive functions in primary school children. J Sch Health. 2016;86.
23. Vetter M, O'Connor HT, O'Dwyer N, Chau J, Orr R. Maths on the move': Effectiveness of physically-active lessons for learning maths and increasing physical activity in primary school students. J Sci Med Sport. 2020;23:735–9.
24. Schmidt SK, Reinboth MS, Resaland GK, Bratland-Sanda S. Changes in physical activity, physical fitness and well-being following a school-based health promotion program in a Norwegian region

with a poor public health profile: A non-randomized controlled study in early adolescents. Int J Environ Res Public Health. 2020;17:1–17.

25. JL. H. The impact of physical activity on academics in english classes at the junior high school level. Diss Abstr Int Sect A Humanit Soc Sci. 2013.
26. Vazou S, Skrade MAB. Intervention integrating physical activity with math: Math performance, perceived competence, and need satisfaction†. Int J Sport Exerc Psychol. 2017;15:508–22.
27. Ludyga S, Gerber M, Brand S, Möhring W, Pühse U. Do different cognitive domains mediate the association between moderate-to-vigorous physical activity and adolescents' off-task behaviour in the classroom? Br J Educ Psychol. 2022;92:194–211.
28. de Greeff JW, Bosker RJ, Oosterlaan J, Visscher C, Hartman E. Effects of physical activity on executive functions, attention and academic performance in preadolescent children: a meta-analysis. J Sci Med Sport. 2018;21:501–7.
29. Ortega FB, Konstabel K, Pasquali E, Ruiz JR, Hurtig-Wennlöf A, Mäestu J et al. Objectively Measured Physical Activity and Sedentary Time during Childhood, Adolescence and Young Adulthood: A Cohort Study. PLoS ONE. 2013;8.
30. Farooq A, Martin A, Janssen X, Wilson MG, Gibson AM, Hughes A, et al. Longitudinal changes in moderate-to-vigorous-intensity physical activity in children and adolescents: A systematic review and meta-analysis. Obes Rev. 2020;21:1–15.
31. Migueles JH, Cadenas-Sanchez C, Ekelund U, Delisle Nyström C, Mora-Gonzalez J, Löf M, et al. Accelerometer data collection and processing criteria to assess physical activity and other outcomes: A systematic review and practical considerations. Sport Med. 2017;47:1821–45.
32. Ruiz JR, Castro-piñero J, España-romero V, Artero EG, Ortega FB, Cuenca MM, et al. Field-based fi tness assessment in young people: the ALPHA health-related fi tness test battery for children and adolescents. Br J Sports Med. 2011;45:518–24.
33. Ruiz JR, España-romero V, Ortega FB, Sjöström M, Castillo MJ, Gutierrez A. Hand span influences optimal grip span in male and female teenagers. Hand Surg. 2006;31:1367–72.
34. Ortega FB, Ruiz JR, España-Romero V, Vicente-Rodriguez G, Martínez-Gómez D, Manios Y, et al. The International Fitness Scale (IFIS): Usefulness of self-reported fitness in youth. Int J Epidemiol. 2011;40:701–11.
35. Alexandra C, Chavarría P. Propiedades de la Utrecht Work Engagement Scale (uwes - s 9): análisis exploratorio con estudiantes en Ecuador Aportes a la Investigación y Docencia. Innovar. 2017;27:145–55.
36. Solano V, Abella VA, Delgado HJV. Determinantes de la calidad, la satisfacción y el aprendizaje percibido de la e-formación del profesorado universitario. Rev Mex Investig Educ. 2018;23:733–60.
37. Mahar MT, Murphy SK, Rowe DA, Golden J, Shields AT, Raedeke TD. Effects of a classroom-based program on physical activity and on-task behavior. Med Sci Sports Exerc. 2006;38:2086–94.
38. Kramer JH, Mungas D, Possin KL, Rankin KP, Boxer AL, Rosen HJ, et al. NIH EXAMINER: Conceptualization and development of an executive function battery. J Int Neuropsychol Soc.

2014;20:11–9.
39. Krueger CE, Bird AC, Growdon ME, Jang JY, Miller BL, Kramer JH. Conflict monitoring in early frontotemporal dementia. Neurology. 2009;73:349–55.
40. Owen AM, McMillan KM, Laird AR, Bullmore E. N-back working memory paradigm: A meta-analysis of normative functional neuroimaging studies. Hum Brain Mapp. 2005;25:46–59.
41. Cadenas-s C, Mart M, De C, Navarrete S, Mar R, Beas-jim JDD, et al. An exercise-based randomized controlled trial on brain, cognition, physical health and mental health in overweight/obese children (ActiveBrains project): Rationale, design and methods. Contemp Clin Trials. 2016;47:315–24.
42. Ravens-Sieberer U, Wille N, Badia X, Bonsel G, Burström K, Cavrini G, et al. Feasibility, reliability, and validity of the EQ-5D-Y: Results from a multinational study. Qual Life Res. 2010;19:887–97.
43. Joffer J, Jerdén L, Öhman A, Flacking R. Exploring self-rated health among adolescents: a think-aloud study. BMC Public Health. 2016;:1–10.
44. González-Cutre D, Sicilia Á, Sierra AC, Ferriz R, Hagger MS. Understanding the need for novelty from the perspective of self-determination theory. Pers Individ Dif. 2016;102:159–69.
45. Baena-Extremera A, Granero-Gallegos A, Bracho CA, Pérez-Quero FJ. Versión española del Sport Satisfaction Instrument (SSI) adaptado a la Educación Física. Rev Psicodidact. 2012;17:377–95.
46. Finn KE, Mcinnis KJ. Teachers' and students' perceptions of the active science curriculum: incorporating physical activity into middle school science classrooms. Phys Educ. 2014;71:234–53.
47. López-Gajardo MA, Leo FM, Sánchez-Miguel PA, López-Gajardo D, Soulas C, Tapia-Serrano MA. KIDMED 2.0, An update of the KIDMED questionnaire: Evaluation of the psychometric properties in youth. Front Nutr. 2022;9.
48. Hobza V, Hamrik Z, Bucksch J, De Clercq B. The family affluence scale as an indicator for socioeconomic status: Validation on regional income differences in the Czech Republic. Int J Environ Res Public Health. 2017;14.
49. Bazeley P, Jackson P. Qualitative data analysis with Nvivo. London: Sage; 2013.
50. Campbell MK, Elbourne DR. Extension To Cluster Randomised Trials. BMJ. 2004;7441:702–8.
51. Masini A, Ceciliani A, Dallolio L, Gori D, Marini S. Evaluation of feasibility, effectiveness, and sustainability of school-based physical activity active break interventions in pre-adolescent and adolescent students: a systematic review. Can J Public Heal. 2022;:1–13.
52. Gammon C, Morton K, Atkin A, Corder K, Daly-smith A, Quarmby T, et al. Introducing physically active lessons in UK secondary schools: feasibility study and pilot cluster-randomised controlled trial. BMJ Open. 2019;9:1–13.
53. Jakicic JM, Kraus WE, Powell KE, Campbell WW, Janz KF, Troiano RP, et al. Association between bout duration of physical activity and health: Systematic review. Med Sci Sports Exerc. 2019;51:1213–9.
54. van den Berg V, Singh AS, Komen A, Hazelebach C, van Hilvoorde I, Chinapaw MJM. Integrating juggling with math lessons: A randomized controlled trial assessing effects of physically active

learning on maths performance and enjoyment in primary school children. Int J Environ Res Public Health. 2019;16:1–13.

55. Pulido-gil JM, Sánchez-oliva D, López- MÁ, Ponce-bordón JC, García-calvo T. Effectiveness of a physically active learning program on indicators of physical activity, well-being and academic performance in students Efectividad de un programa de aprendizaje físicamente activo sobre indicadores de actividad física, bienestar y ren. Cult Cienc y Deport. 2022;17:189–208.

Figures

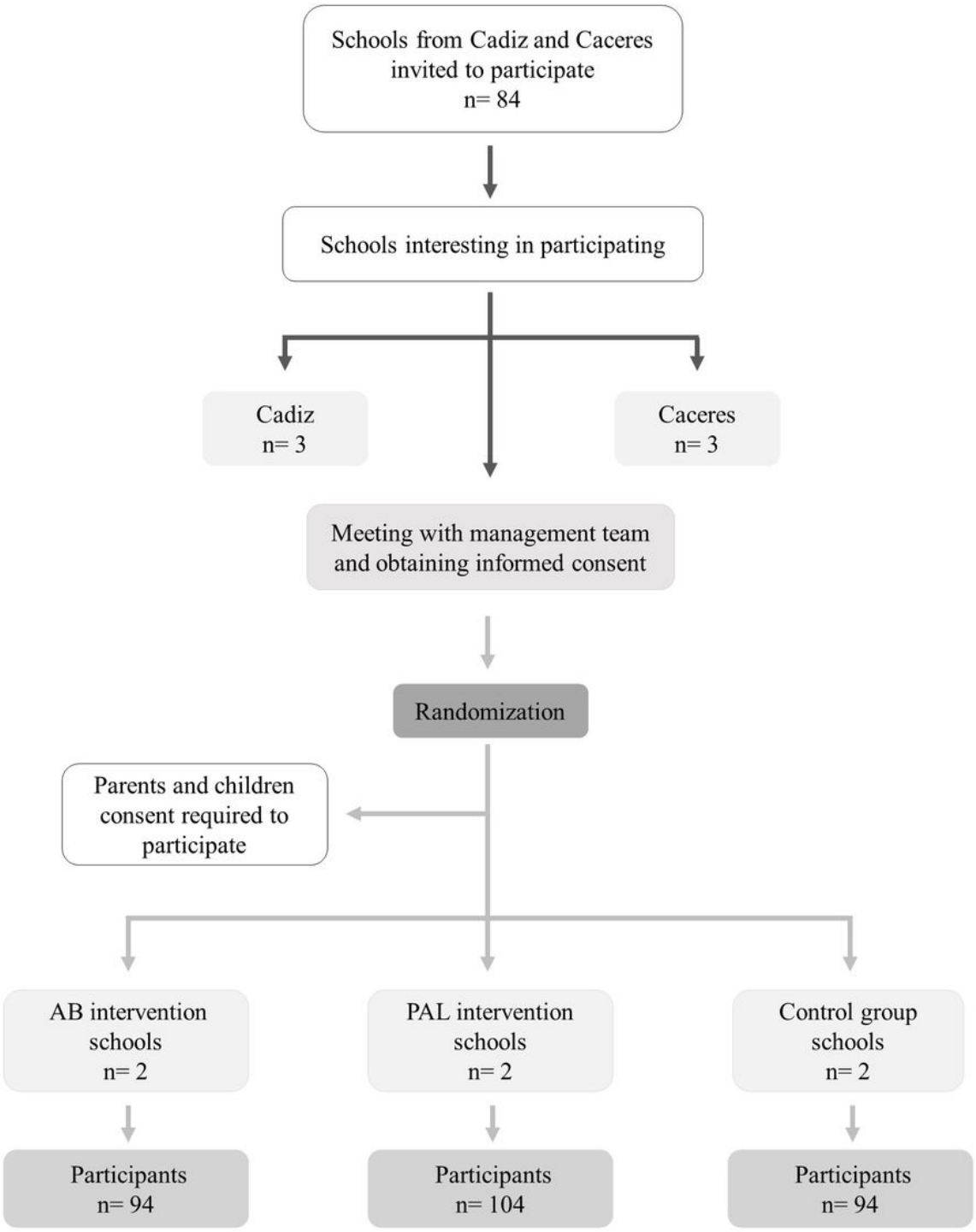

Figure 1

Flow diagram of study participants.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- CONSORT2010Checklist.pdf
- StudyProtocol.docx