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Increasing adolescents' physical activity levels through a comprehensive school-based physical activity program: study protocol of the cluster randomized controlled trial *Active School*

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Abstract

Background The positive effects of regular physical activity on children and adolescents' physical and mental health are well-established. Despite these health benefits, most Swiss adolescents do not meet WHO's recommended level of physical activity, which includes a daily minimum of 60 min of moderate-to-vigorous physical activity. Due to their inclusivity, schools are identified as a key setting to promote physical activity. Recently, the comprehensive school physical activity program (CSPAP), in which teachers as physical activity leaders (PALs) play a crucial role to advance comprehensive school-based physical activity promotion, has been discussed. However, such comprehensive approaches are still lacking in Switzerland, and specific PAL trainings do not exist. Therefore, the aim of this study is to implement and evaluate *Active School*, a comprehensive school-based physical activity program for Swiss secondary schools with integrated PAL training.

Methods/design A cluster randomized controlled trial (RCT) involving 12 secondary schools (6 experimental, 6 waiting control schools) will assess baseline data and effectiveness of *Active School* at 12 and 24 months. *Active School* includes five components based on the CSPAP. Each school is encouraged to set individual physical activity goals in this regard. This process is guided by the PALs, who will participate in professional development training before and during *Active School* implementation. As a primary outcome, students' moderate-to-vigorous physical activity will be assessed via accelerometers. As secondary outcomes, inactivity, light physical activity, step counts, aerobic fitness and coordination will be measured, and students' general wellbeing, learning behavior, and multiple psychosocial measures related to physical activity will be assessed by questionnaires. The effectiveness evaluation is accompanied by a process evaluation that focuses on the implementation outcomes of dose of delivery, reach, feasibility, and sustainability. A mixed methods approach, including ripple effect mapping, will be employed to reconstruct and understand the implementation process.

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Discussion This study will be the first to implement and evaluate a CSPAP in the Swiss school system. The specific PAL training and the simultaneous application of effectiveness and process evaluation are considered strengths of the study.

Trial registration German Clinical Trials Register (DRKS00033362). Date of registration: January 25, 2024. Retrospectively registered.

Keywords Comprehensive approach, Physical activity, Secondary school, Adolescents, Physical activity leader, Process evaluation, Effectiveness evaluation

Background

Children and adolescents are becoming increasingly sedentary, with their physical activity behavior being characterized by a lack of exercise [1]. Regular physical activity declines, especially in adolescence. As a result, 80% of adolescents do not meet the daily physical activity recommendations of 60 min of moderate-to-vigorous physical activity (MVPA) [2]. This global trend is also evident in Switzerland, as over half of Swiss adolescents fail to meet the daily physical activity recommendations [3]. The prevalent physical inactivity pattern is worrying because it is associated with far-reaching negative effects on adolescents' health, subsequently leading to high healthcare costs for society [4]. Moreover, inactivity and irregular physical activity in adolescence are often connected with inactivity in adulthood [5], increasing the risk of chronic diseases later in life [6]. It is well known that the health benefits of regular physical activity for adolescents are extensive including reduced risk for obesity as well as improved physical fitness, cognitive functions, and mental health [7, 8].

Since adolescents spend a considerable part of their day at school, schools seem to play a pivotal role in promoting physical activity for all students. This is also supported by studies that have identified schools as a key setting with potential for high impact [9]. According to international guidelines, it is recommended that students participate in a minimum of 30 min of MVPA at school, which includes physical education classes [10]. Unfortunately, most schools do not provide enough opportunities for physical activities. Results of a European cross-sectional study indicate that Swiss adolescents spend 65% of their school time sitting and only 5% in MVPA, which is below the recommended average of 30 min [11], highlighting the need for effective interventions for this population.

In recent years, many school-based physical activity interventions have been implemented [12]. Although school-based physical activity interventions are considered effective [13, 14], sustaining positive effects over an extended period remains challenging [15, 16]. Thus, the KISS study in Swiss schools showed significant increases in MVPA during the intervention year [17] but failed to maintain these effects in the long term [18]. However, this intervention was relatively controlled by researchers, who prescribed the physical activity measures with little room for adaptation.

To address these challenges, it is crucial to focus on the adaptability of interventions to ensure their long-term success [19]. Physical activity interventions often encounter numerous barriers, particularly at the teacher level, including lack of time, confidence, motivation, and resources to deliver physical activity measures [20–22]. Therefore, interventions should be designed to fit the unique contexts of individual schools and integrate stakeholder perspectives in the planning stages [23]. This ensures that the intervention meets the specific needs and capacities of each school, facilitating better buy-in and sustainability.

In the recent scientific discourse, comprehensive approaches are therefore increasingly discussed. For example, the comprehensive school physical activity program (CSPAP) promoted by the US Center for Disease Control and Prevention represents such a comprehensive approach by addressing three important aspects [24]: 1) Physical activity leaders (PALs; experienced physical education teachers recommended) play a central role [25] and are responsible for physical activity promotion, support, and accompaniment of all participants. Internal leadership appears to be a critical factor in the successful implementation of physical activity measures [20]. 2) Physical activity promotion can be addressed in a variety of school settings since an expansion of physical activity options is considered a key element in increasing students' physical activity levels [26]. 3) The schools are encouraged to develop individually tailored physical activity goals and subsequent possibilities for implementation since suitability and autonomy in program design and delivery seem to increase the engagement and motivation of the school staff [23, 27].

In English-speaking countries, such comprehensive approaches are already more established, with some evidence supporting its effectiveness in enhancing daily physical activity in youth [28–31]. For instance, the comprehensive project PA4E from Australia significantly increased the MVPA level of adolescents after 12 months of program duration [28]. These effects persisted even

after 24 months [29]. Furthermore, it has been shown that increased physical activity also improves a wide range of outcomes. Therefore, previous findings suggest that comprehensive school-based physical activity interventions can also lead to positive effects in physical fitness, motor skills, wellbeing, learning behavior, and social-emotional learning, which is crucial for a positive class- and school climate [32–34]. In German-speaking countries, however, CSPAPs are still missing. In Switzerland, particularly, physical activity programs are often implemented at the level of individual classes rather than at the school level [35, 36]. Thus, there is a need to start implementing comprehensive school-based physical activity programs in the Swiss school system.

To truly achieve positive effects of comprehensive approaches, it is also essential to consider their challenges [37]. Special attention must be given to internal leadership, specifically the PALs [24, 38]. Due to their new roles and responsibilities, they need to develop leadership skills beyond their regular teaching profession, which altogether often results in insufficient time for their normal duties [39]. Therefore, it is crucial that PALs receive adequate support from the school environment as well as external resources [40]. Emphasis should be placed on the importance of professional development (PD) trainings [41] with integrated and regular mentoring [37], as studies have shown that trained PALs implement significantly more physical activity opportunities [42].

Recognizing the positive impact of a specific PAL PD training, it appears crucial to incorporate such a component when implementing CSPAP in the Swiss school system.

Isolated PAL PD trainings exist [25], but they have predominantly been designed for the Anglo-American context. However, differences in culture and language prevent these programs from being directly applied to the Swiss school system, necessitating adaptations [13, 14, 43].

Concerning the evaluation of comprehensive approaches, several methodological issues must be considered because of their complex intervention characteristics [44, 45]. Due to the multi-layered nature of a CSPAP and its high flexibility, implementation varies greatly across schools, which is important to consider as implementation effectiveness in physical activity interventions is known to be linked with positive outcome measures [20, 32]. Thus, to make an accurate statement about the program's (in)effectiveness, it is recommended that additionally process evaluations be conducted, which provides information on understanding the outcomes by a more detailed analysis of how the program works and why [15, 37]. To do so, an understanding of the specific implementation in each school is required [20]. Therefore, the description and assessment of the implementation are necessary and involve the identification of outcomes and additional determinants at the support and delivery levels of the individual school [46, 47].

Based on recent findings, we will implement a CSPAP called *Active School* in the Swiss secondary school system to increase students' physical activity, which will consist of a specified PAL PD training. To evaluate *Active School* and analyze whether the program was implemented as intended, we are conducting the evaluation in two strands: the effectiveness evaluation, which measures physical activity behavior at the student level, and the process evaluation, which analyzes specific variables at the support and delivery systems.

Methods and design

Study aims and hypotheses

This study has two purposes:

First, this study will examine whether the comprehensive school-based physical activity program *Active School* effectively promotes increased physical activity in adolescents (effectiveness evaluation). It is assumed that *Active School* will result in an increase in the primary outcome MVPA level among students compared to the waiting control schools and that this increase will be sustained after 12 and 24 months of *Active School* implementation. In addition, it will be examined whether *Active School* may exert a positive effect on the secondary outcome measures, which can additionally be influenced by the intervention, namely inactivity, light physical activity, step counts, aerobic fitness, coordination, self-reported physical activity, general wellbeing (subjective wellbeing, classroom climate, school wellbeing), and learning behavior. To gain a deeper understanding of how physical activity is influenced, we also assess psychosocial factors (physical self-concept, motivation for exercise, physical activity environment in school) that may mediate physical activity participation [48–50].
Second, the study will investigate the implementation process to understand how the schools implement *Active School* (process evaluation). The implementation of *Active School* is based on the framework for effective implementation [47]. Since schools independently plan, conduct, and evaluate their physical activity measures, the entire internal development and implementation process will be systematically documented and reconstructed to enable the process evaluation in each school. The process evaluation will focus on the implementation outcomes, dosage of delivery, reach, feasibility, and sustainability among

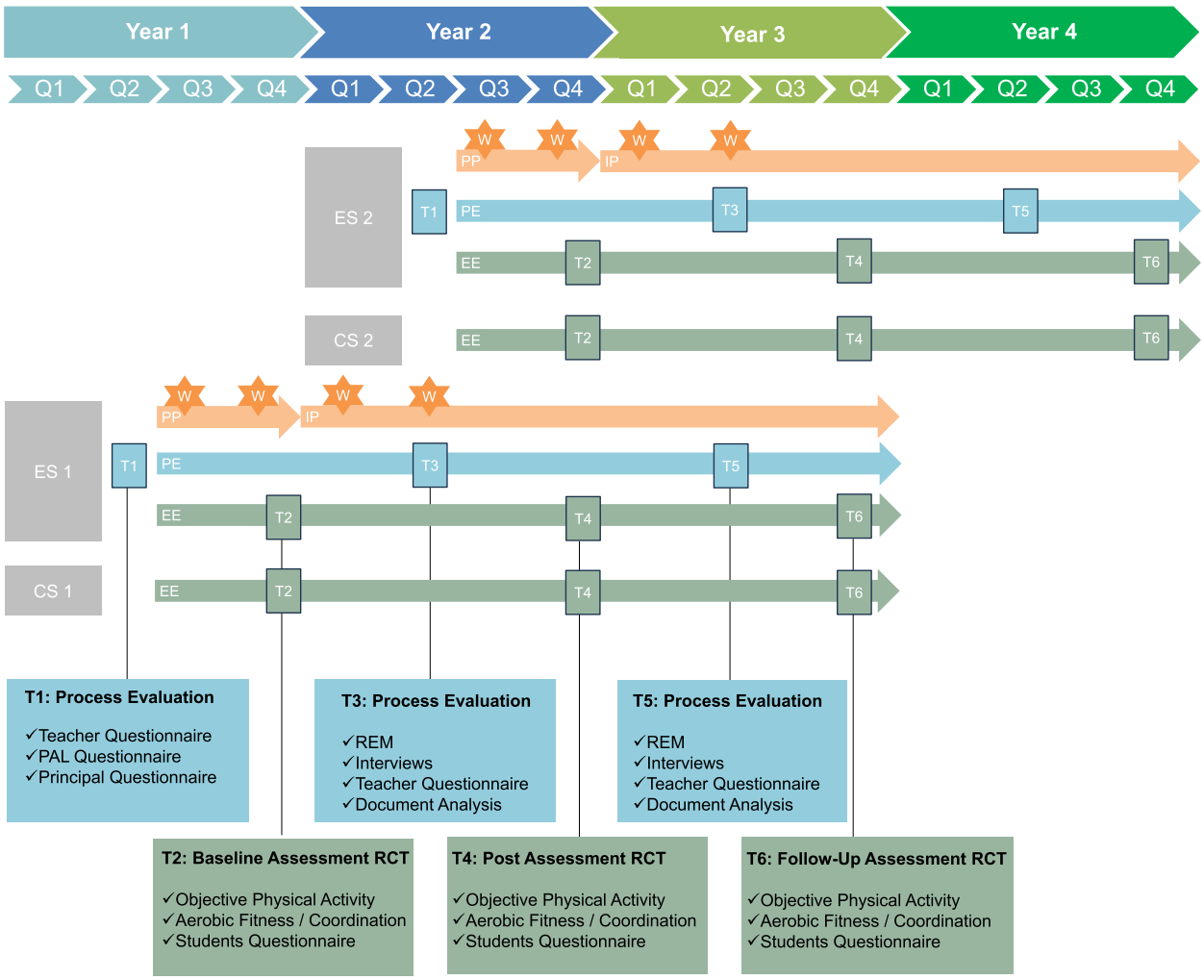

Fig. 1 Intervention and measurement timeline. *Note: Q1-Q4* = quarter 1-quarter 4, *ES1 & 2* = experimental schools cohort 1 & 2, *CS1 & 2* = waiting control schools cohort 1 & 2, *PP* = *Active School* preparation phase, *IP* = *Active School* implementation phase, *PE* = process evaluation, *EE* = effectiveness evaluation, *W* = PAL workshops, *REM* = ripple effect mapping

the support and delivery systems of the schools [46]. Further implementation determinants related to context, provider, program characteristics, and characteristics of the program delivery and support systems will be analyzed [47].

Study design

A cluster randomized controlled trial (RCT) involving 12 secondary schools (1:1 allocation: 6 experimental, 6 waiting control schools) will be conducted for the effectiveness evaluation. Two cohorts, each comprising six schools (3 experimental and 3 waiting control schools), will be recruited, initiating their participation in *Active School* with a one-year offset (see Fig. 1). The primary and secondary outcomes will be measured at baseline assessment (T2), after 12-month post assessment (T4) and at a 24-month follow-up assessment (T6). The six schools of the waiting control group will continue their routine as usual and are not allowed to implement any specific school programs to promote physical activity. The schools can access all project-specific materials at the end of *Active School,* and the teachers are given the opportunity to attend the same PAL PD training. A waiting control design was deliberately chosen to mitigate the control school's disappointment over not participating in the project, thereby maintaining their motivation for assessments.

Qualitative and quantitative data collection will be conducted at the 6 experimental schools for the process evaluation. At the beginning of the *Active School* preparation phase (T1), the personal, spatial, temporal, and financial resources for promoting physical activity

within the school will be assessed. After a 6-month (T3) and 18-month (T5) *Active School* implementation phase, data on the implementation outcomes as well as further implementation determinants will be collected through a mixed-methods data collection, using document analysis, ripple effect mapping (REM), semi-structured interviews, and questionnaires.

Setting

Active School will be conducted in three different regions of the Swiss canton of Bern (Bernese Oberland, Bernese Mittelland, Bernese Emmental). These regions are geographically widely dispersed and include urban areas with cities and regional/rural areas. The canton of Bern was chosen for the study because its geographical characteristics reflect a representative image of Switzerland. Secondary schools in the canton of Bern are aimed at students aged 12–16 (7th to 9th grade) and run for two semesters per calendar year. Swiss secondary schools are obliged to offer students three lessons of physical education (135 min in total) per week. The canton of Bern recommends the implementation of additional school-based physical activities, but these are not mandatory.

Sample size

We used the R package powerlmm [51] to conduct a power analysis for a longitudinal multilevel model. Based on previous studies analyzing the effectiveness of comprehensive approaches, we set the effect size for differences in MVPA level (primary outcome) between study arms at 0.25 [31]. The baseline intraclass correlation coefficient (ICC) at the school level was set to 0.01 [52] and at the student level to 0.70 [53]. Based on a 65% rate of the cohort contributing valid data at the 24-month follow-up [54] the dropout rate was set to 0.35. With six schools per arm, a minimum of 45 students per school and tree time points analysis indicated a power of 0.81. Hence, it will be necessary to recruit a total of 12 schools (6 experimental and 6 waiting control schools) and a minimum of 540 students in total.

School recruitment, selection and randomization

Active School will be advertised through various channels (e.g., newsletters from the Bern University of Teacher Education, presentations at cantonal sports teacher training courses). The cantonal sports government will also support the recruitment by sending a project invitation to all eligible secondary schools in Bern via the cantonal e-mail database. The schools must fulfill various criteria to be included in the project: (1) cantonal public or semi-public schools; (2) students in grades 7–9; (3) at least two classes per school level; (4) no talent- /art- / or boarding schools; (5) no participation in other major school projects in the area of physical activity promotion; (6) schools must have at least two interested teachers who are willing to take on the role of PAL. Whether the first four criteria are met is determined based on publicly available data. The fifth and sixth criteria are evaluated based on contacts with school principals during recruitment. Interested schools will be contacted by the project coordinator, who will then hold individual meetings with the school principals and potential PALs.

After recruiting, stratified randomization will be carried out through the research team with one stratum and with the requirement of an even distribution of schools from diverse regions of the canton of Bern (Bernese Oberland, Bernese Mittelland, Bernese Emmental) to the experimental schools and the waiting control schools. The two strata will be defined according to school typology based on the school's geographical location. Stratum A: rural school; Stratum B: urban school. Starting with stratum A, schools will be randomly assigned to either the experimental or waiting control schools. After randomization, an agreement will be signed with all school principals in which the form of collaboration with the research team is set out for the project's duration. The first part of the RCT is shown in Fig. 2.

Intervention

Active School is based on the CSPAP promoted by the US Center for Disease Control and Prevention [24]. *Active School,* therefore, incorporates five core components of physical activity promotion in school, focusing on 1) Physical Education, 2) Physical Activity During School, 3) Physical Activity Before and After School, 4) Staff Involvement, and 5) Family and Community Engagement. In implementing *Active School*, each school can prioritize and enhance physical activity in any of the five core components. This allows schools to tailor their approach autonomously based on individual goals and needs, promoting a customized and adaptable strategy to foster physical activity within their unique context. PALs will undergo the PAL PD training provided by the research team to be prepared for their role as the leaders of *Active School* at their schools. Subsequently, teachers at the respective school will be guided and supported by the PALs in implementing various physical activity measures derived from the school's individual goals.

Physical Activity Leader (PAL)

Regarding the PALs tasks, two areas can be distinguished: creating facilitating conditions for the implementation of measures promoting physical activity in the areas explained above (support system) and planning, executing, and evaluating these measures

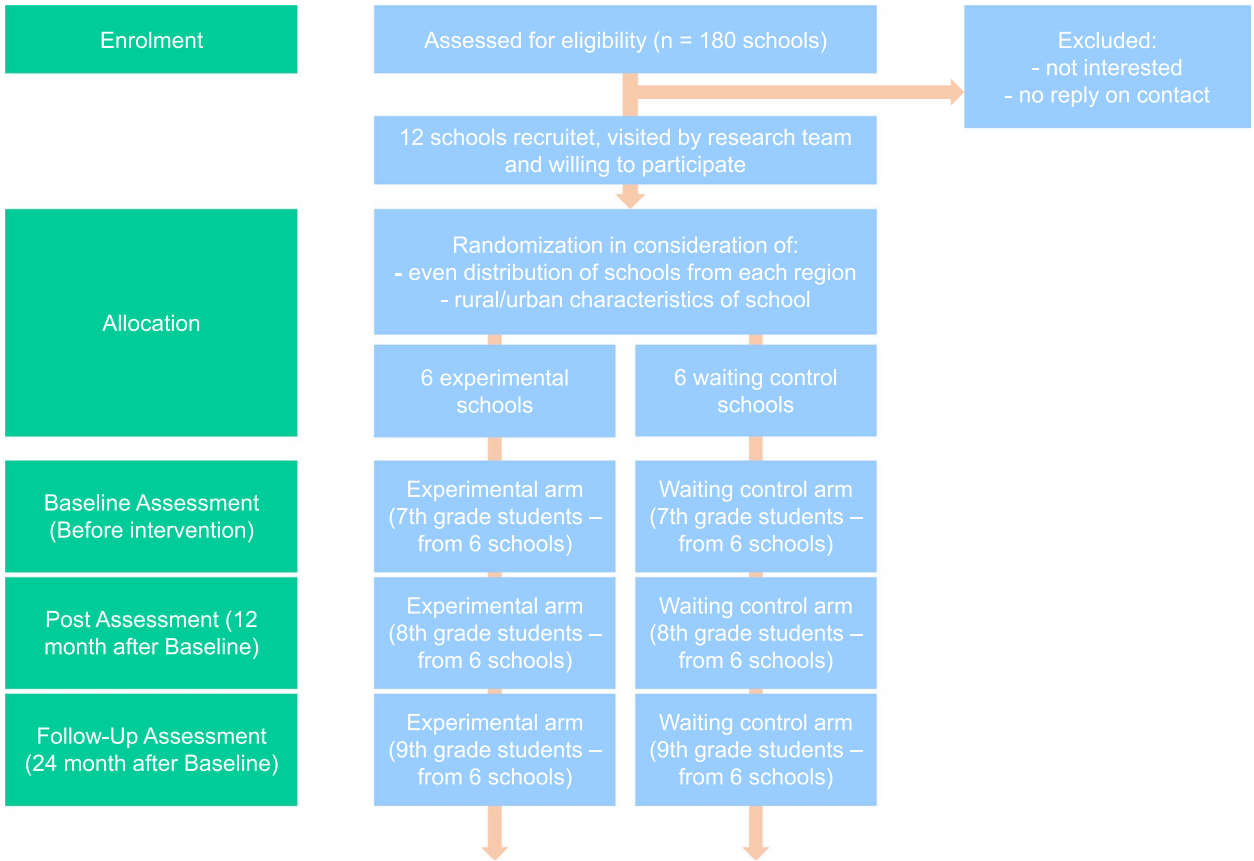

Fig. 2 Flow Diagram of the RCT

involving all school stakeholders (delivery system). For the implementation of *Active School*, PALs apply several strategies that include implementation, capacity-building, dissemination, and integration [55]. The PALs should employ these strategies to establish a support system for the teachers and staff at their school, enabling the implementation of physical activity measures for students (see Fig. 3).

Each experimental school must provide two PALs who take on the role together. All PALs are regular teachers from the respective school who should be committed and motivated for the new task, and ideally familiar with physical education as well as the classroom setting. Like the schools, PALs commit to implementing *Active School* at their respective schools for 2.5 years. Additionally, PALs will be compensated for their work with one paid hour per week. This compensation ensures that they are adequately supported and motivated to fulfill their responsibilities effectively. Each experimental school also compiles a physical activity committee (PA committee), which the PALs lead. The PA committee consists of up to five different representatives of the school (e.g., interested teachers, school principals, students, and janitor). It supports the PALs in establishing good conditions for the implementation of *Active School* within the support and delivery systems.

PAL professional development training

The PAL PD training will comprise a) the transfer of strategies for implementing specific school-based physical activity promotion measures and b) considerations of strategies for supporting the delivery of these measures. Therefore, the PAL PD training consists of 4 workshops, regular exchanges with the research team, and technical support provided by the research team. The 4 workshops take place over a year and will be conducted in person, bringing together all PALs from the different schools. This group setting is chosen to facilitate personal contact and beneficial exchanges among the PALs. Each workshop will last for 3 to 4 h and will be scheduled on a non-school afternoon. The workshops are designed to build knowledge and develop strategies that can be applied in practice. This hands-on approach [41] ensures that participants are not only learning theoretical concepts but also gaining practical

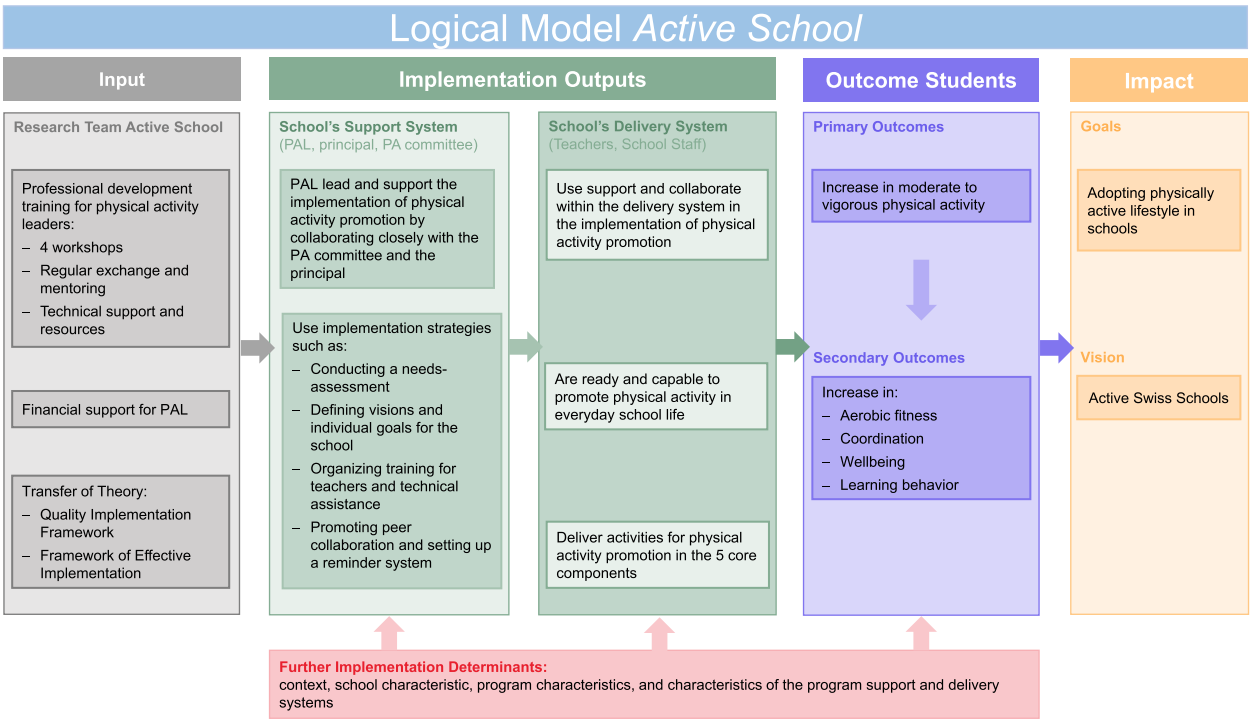

Fig. 3 Logical Model *Active School*

skills that they can implement in their daily work settings. During the preparation phase (PP, see Fig. 1), two workshops take place to prepare structures for the later implementation at the schools. There is no delivery of measures for physical activity promotion in the PP. During the implementation phase (IP, see Fig. 1), two additional workshops take place. From the beginning of this phase, measures will be delivered within the core components of *Active School*.

The workshops are based on Meyers and colleagues' Quality Implementation Framework [56]. During the workshops, PALs will learn the following strategies [55]:

1) Implementation process strategies

- Conducting a needs-assessment (e.g., the wishes, concerns and needs of the school staff and students)
- Building a physical activity committee
- Defining visions and objectives
- Selecting, adapting, and planning physical activity promotion measures that fit the school's needs
- Evaluating processes and outcomes

2) Capacity-building strategies

- Organizing training for teachers
- Supporting implementation by technical assistance
- Promoting peer networking and cooperation

3) Dissemination strategies

- Developing and promoting physical activity measures
- Development, procuring, and providing materials

4) Integration strategies

- Setting up a reminder system for the delivery system
- Scheduling specific periods or windows for exchange

At the first workshop, PALs will be briefed on *Active School* and implementation strategies to conduct initial considerations regarding their school setting. During the second workshop, PALs will acquire additional implementation, capacity-building, and dissemination strategies to create structures for implementation at their school. The third workshop will focus on integration and dissemination strategies on the one hand and discuss ongoing work at the school on the other. The PALs should be empowered to maintain and expand the structures for support once the implementation has begun. The fourth

workshop will focus on evaluating and improving the internally implemented measures at the schools.

Regular exchange and collaboration between the PALs and the research team are planned throughout the entire project duration. In the first year, this exchange will occur during the workshops and individually scheduled online meetings, aiming to support the PALs in implementing the *Active School* effectively. In the following years of the IP, biannual meetings will be scheduled to support the exchange between the schools. Additionally, each PAL will be assigned a mentor from the research team who will serve as their primary contact for any questions or concerns. This mentoring system is crucial as it provides ongoing support and guidance, ensuring that PALs feel confident and capable in their roles [41]. Mentoring helps to enhance the implementation of physical activity programs by offering personalized and regular assistance and ensuring consistency in program delivery through the setting of milestones [37]. This support system is vital for maintaining motivation, addressing challenges promptly, and fostering a collaborative environment conducive to the successful promotion of physical activity within schools.

Technical support will be provided by the research team on the levels of the school's support and delivery system. PALs have access to digital templates for planning, conducting, and evaluating the school's measures, which support the execution of implementation strategies. To foster physical activity measures, schools can access an extensive online collection of materials and ideas for school-based physical activity promotion in all five core components of the *Active School*. This collection is intended to facilitate the application of capacity-building and dissemination strategies.

Participants

Effectiveness evaluation

According to the power analysis, at least 540 students (12–16 years) will be recruited. All students from the 7th grade at each experimental and waiting control school are eligible to participate in the RCT measurements and will be invited to take part in the study. The students therefore complete the baseline assessment (T2) in the 7th grade, the post assessment (T4) in the 8th grade, and the follow-up assessment (T6) in the 9th grade (see Fig. 2). Students who are injured or sick and consequently unable to engage in their usual physical activity routines will not be included in the analysis for the respective measurement time point.

Process evaluation

To accurately map the implementation process through *Active School*, various stakeholders engaged in designing and delivering measures within the school's support and delivery systems will be involved in the process evaluation. 12 PALs (two in each experimental school), 6 principals, and the members of the 6 PA committees (one in each experimental school) will be included in the process evaluation. In addition, all teachers from the experimental schools will be invited to complete an online questionnaire to gain a deeper understanding of their perspectives.

Procedure

Effectiveness evaluation

The research team will provide a consent form to the students, which requires a parental signature (see ethics approval and consent to participate for further detail). To motivate the students to wear the accelerometer, they will get incentives at each measurement time point if they adhere to the wearing conditions. Research assistants, who will be blinded about the group assignments of the schools, will be trained to practice the standardized test procedure to collect all outcome variables. Also, the statistician will remain blind to the study group by utilizing various treatment codes.

Process evaluation

Before the commencement of the implementation process, *Active School* and the planned surveys will be introduced to the teachers at all experimental schools, and the principals will obtain their consent. The collaboration between the research team and schools will be initiated by signing an agreement in which the Principals and PALs commit to implementing *Active School* and participating in process evaluations.

The process evaluation consists of qualitative data collection through ripple effect mapping (REM), semi-structured interviews, and quantitative data collection through a teacher questionnaire. The REMs will be conducted on-site with the entire physical activity committee at each experimental school. The previously gathered documents (e.g., PAL protocol) will be used to create a timeline on Miro [57], including key events of the implementation process. This timeline is utilized during the REMs to document the school's implementation process. After the REM, the implementation process of each experimental school will be digitally mapped on Miro. Research assistants will undergo training in advance to practice the mapping process during the REM workshops. For the semi-structured interviews, appointments with principals and PALs will be scheduled following the REM. If necessary, additional PA committee members will be interviewed for a comprehensive understanding of the

Table 1 Students measurements at each time point (following SPIRIT template [59])

	Time Point		
	T2	T4	T6
Primary Outcome			
MVPA	x	x	x
Secondary Outcomes			
Inactivity	x	x	x
Light Physical Activity	x	x	x
Step Counts	x	x	x
Aerobic Fitness	x	x	x
Coordination	x	x	x
Self-reported Physical Activity	x	x	x
Subjective Wellbeing	x	x	x
Classroom Climate	x	x	x
School Wellbeing	x	x	x
Learning Behavior	x	x	x
Physical Self-Concept	x	x	x
Motivation for Exercise	x	x	x
Physical Activity Environment in School		x	x
Students characteristics			
Socioeconomic Status	x		
Family Health Climate	x		
BMI	x	x	x

MVPA Moderate-to-vigorous physical activity, *BMI* Body mass index

implementation process. The interviews will be conducted on-site at the school and documented through audio recordings. For the transcription of the interviews, the AI-based software noScribe [58] is used. The teacher questionnaire will be integrated into a school internal teacher meeting.

Measurements

Effectiveness evaluation

At all three measurement time points (T2, T4, T6), the students' objective physical activity, aerobic fitness and coordination will be measured, and the student questionnaire will be conducted (see Table 1).

Objective physical activity

Objective physical activity will be assessed with the GENEActiv accelerometer (Activinsights Ltd, Kimbolton, UK). Students will wear the GENEActiv accelerometer continuously for seven days, i.e., 24 h per day, on their non-dominant wrist. Physical activity data analysis will include participants with at least 10 h of wear time per 24-h period on at least four days [53]. GENEActiv accelerometers are validated for the adolescent age group [60] and have been used in various studies focusing on school-based physical activity promotion [30, 61]. Since the devices are waterproof and highly durable, they can be worn during all activities. Students will be instructed to keep the accelerometer on throughout the entire measurement week. The following variables will be recorded with the GENEActiv devices: MVPA, inactivity, light physical activity, and step counts. To define the various intensity levels, the cut points from Phillips et al. [60] will be used, as they are best suited to the age range of our study population.

Student characteristics

Students will be asked to report their date of birth and sex. Standing height and weight will be measured using standardized procedures. Weight will be measured to the nearest 0.1 kg using a digital scale (EBS002K, Esperanza). Height will be measured to the nearest 0.1 cm using a portable stadiometer (Anthroflex, NutriActiva, Germany). Participants will be asked to remove their shoes and any heavy clothing before measurements are taken. Body mass index (BMI) will be calculated, taking into account sex and age [62]. The socioeconomic status of the students will be assessed using the Family Affluence Scale III (FAS III) [63] and the family health climate using the Family Health Climate Scale (FHC-scale) [64].

Aerobic Fitness and coordination

Aerobic fitness will be assessed by the 20-m shuttle run test [65]. To measure coordination, the test item jumping sideways from the German Motor Test 6–18 (GMT 6–18) will be used [66]. The trained research assistants will conduct the testing. It will take place during a physical education class in the gymnasium, with each session accommodating a class group. Each research assistant will be responsible for approximately 5 students, recording the results individually on an evaluation sheet.

Students questionnaire

Self-reported physical activity, general wellbeing, learning behavior, and multiple psychosocial measures related to physical activity will be assessed using the students' questionnaire. Self-reported physical activity will be assessed using the MoMo Physical Activity Questionnaire (MoMo-PAQ) for adolescents, which measures physical activity in different settings [67]. In this study, we considered the settings overall physical activity (2 items), school (9 items), sport club (2 items), and leisure-time (3 items). Four additional specially developed items will be used to delve more specifically into physical activity in the educational setting. These items inquire how often

students engaged in the following physical activities at school during the preceding school week: learning while standing, physically active learning, movement breaks, and physical activity homework. General wellbeing will be assessed using the KIDSCREEN-10 [68], which measures subjective wellbeing (10 items); the classroom climate scale of the Questionnaire for the Assessment of Emotional and Social School Experiences (FEESS 3–4) [69], which measures the classroom climate (11 items); and the wellbeing in school scale of the Linzer Questionnaire on School and Class Climate Assessment (LFSK 4–8) [70], which measures school wellbeing (2 items). Learning behavior will be assessed with two subscales (Endurance, Concentration) of the Self-report Checklist for Social and Learning Behavior (SSL) (4 items each) [71]. Regarding psychosocial measures related to physical activity, we will assess physical self-concept using the Physical Self-Concept in Children Questionnaire (PSK-K) (21 items) and the Physical Self-Description Questionnaire (PSDQ-S) (subscale physical self-esteem, 3 items) [72, 73]; motivation for exercise using the Behavioral Regulation in Exercise Questionnaire 2 (BREQ-2) (19 items) [64, 74]; and school physical activity environment using the Questionnaire Assessing School Physical Activity Environment (Q-SPACE) (13 items) [75].

Process evaluation

The variables collected before implementation (T1) serve to determine the initial situation of the schools. These results will be fed back to the PALs during the PD training, thereby supporting them in planning appropriate measures that meet the specific needs and conditions identified at their schools. Based on these T1 conditions, the implementation outcomes and determinants are analyzed at the measurement points T3 & T5 (see Table 2).

Principal questionnaire

We will assess principals' perceptions of school-based physical activity promotion using a self-developed questionnaire that measures opportunities for physical activity promotion of the five core components (see chapter intervention) as well as guidelines, leadership, and requirements for school-based physical activity promotion. The questionnaire items are based on the CSPAP-Q questionnaire [76] and the Creating Active Schools Organisational Change Questionnaire [77].

PAL questionnaire

The PAL questionnaire serves to obtain a descriptive characterization of the PALs. Therefore, PALs will provide demographic information, including age, sex, years of teaching experience, educational qualifications, and whether they are certified physical education teachers. To assess PAL's physical activity background, their attitudes toward sports participation will be measured using the Questionnaire for Measuring Attitudes Toward Sports Participation [78]. Additionally, we will inquire PALs about their task-specific self-efficacy using the German version of the Norwegian Principal Self-Efficacy Scale (SWE) [79]. The intro sentence and the wording of the scale were specifically adapted for the tasks of the PALs.

Teacher questionnaire

The teacher questionnaire serves as a comprehensive instrument for gathering various pertinent information related to school-based physical activity promotion among teachers from experimental schools. Therefore, teachers will provide the same demographic information as the PALs. To assess teachers' physical activity background, their attitudes toward sports participation will be measured using the Questionnaire for Measuring Attitudes Toward Sports Participation [78], and their self-reported physical activity will be measured using the Godin-Shephard Leisure-Time Physical Activity Questionnaire (GSLTPAQ) [80]. Teachers' self-efficacy in providing classroom physical activity will be measured using the Teacher Efficacy Towards Providing Physical Activity in Classroom Scale (TETPPACS) [81]. To measure teachers' implementation of classroom physical activity, four additional specially developed items based on Bund et al. [82] will be used regarding the frequency of standing learning, movement breaks, physically active learning, and physical activity homework during the past school week. Furthermore, the implementation of school-based physical activity promotion will be assessed using the Health Promotion School Implementation Instrument (HPS) [83]. The intro sentence and the wording of the scale were specifically adapted to the topic of school-based physical activity promotion.

Additionally, teachers will be queried with project-specific items. Therefore, their specific readiness for change and their intention to change will be measured [84]. Teachers' perceived acceptability and appropriateness of *Active School* will be measured using the German version of the Acceptability of Intervention Measure (AIM) and the Intervention Appropriateness Measure (IAM) [85]. Their motivation toward *Active School* will be assessed using the Work Task Motivation Scale for Teachers (WTMST) [86]. Furthermore, job satisfaction will be assessed using a single item [87].

Document analysis

The documents created by the PALs and the PA committees provide insights into the ongoing work and the establishment of support and delivery systems of the

Table 2 Data collection methods of the process evaluation

Data collection methods	Support system	Delivery system
Principal questionnaire	Supporting opportunities of the school, including guidelines/leadership/requirements: all Principals (T1)	PA opportunities of the school including core components /guidelines/requirements: all Principals (T1)
Physical activity leader questionnaire	PALs characteristics including background/attitudes towards sports participation/self-efficacy: all PALs (T1)	
Teacher questionnaire		Teacher characteristics including background/attitudes towards sports participation/self-reported physical activity/self-efficacy, level of implementation, and project specific items including readiness for change/intention to change/acceptability/appropriateness/motivation/job satisfaction: all teachers (T1, T3, T5)
Document analysis	Protocol including actions and decisions within the physical activity committee, further documents created during the implementation process by the physical activity committee: all available documents (T3, T5)	
Ripple effect mapping	Activities and decisions in the support system, implemented strategies including implementation/capacity-building/dissemination/integration strategies, and facilitators, and barriers for the implementation: all physical activity committees (T3, T5)	Activities and decisions in the delivery system, implemented PA measures, facilitators, and barriers for the implementation: all physical activity committees (T3, T5)
Semi-structured interviews	Personal judgment regarding the current establishment of a support system, including the personal role in the process/dose of delivery/reach/feasibility/implementation determinants based on the process mapping: all principals, all PALs, additional key members of the physical activity committees (T3, T5)	Personal judgement regarding the current implementation of PA measures, including the personal role in the process/dose of delivery/reach/feasibility/implementation determinants based on the process mapping: all principals, all PALs, further key members of the physical activity committees (T3, T5)

PALs Physical activity leaders, *PA* Physical activity

experimental schools, including information on decisions, implemented measures, and implementation challenges [88]. All created documents will be digitally stored for access by the research team and included in qualitative analysis. Using the provided templates, the PALs will protocol continuously all meetings with the principal, agendas, and decisions from PA committee meetings, collaboration and planning sessions with teachers, and other important events within *Active School*. Furthermore, the tasks of the PA committee will be documented, along with their allocation to individual committee members. Additionally, the needs-assessments, visions, goals, measures, evaluation tools, and results developed in the PA committee in collaboration with teachers are documented.

Ripple Effect Mapping (REM)

REM is a qualitative approach to gathering data on the broader impacts of an intervention and the implementation process in collaboration with the implementation's stakeholders [89, 90]. REM is designed to reveal a wider spectrum of a program's intended and unintended effects. This is particularly crucial in comprehensive system programs and situations where interventions are adaptable, evolving, and collaboratively produced [90]. Hence, this method is suitable for evaluating the implementation of *Active School*. The REM takes place during a meeting led by the research team. To gain insight into the implementation process of *Active School,* the REM will be carried out with the PA committees of the experimental schools. The goal is to generate a visual representation of the implementation process in the support and delivery systems of the schools. The approach proposed by Chazdon et al. [89] will be adapted to ensure the reconstruction of the processes in the support and delivery systems. The sessions consist, therefore, of the following four steps: team-based discussion and mapping of all activities and impacts regarding the support system of the school, team-based discussion, and mapping of all activities and impacts regarding the delivery systems, further reflection on the implementation process to identify facilitators and barriers, conclusions on the current implementation process and outlook. With REM, the activities and impacts of the PA committee implementing *Active School* will be visually mapped along the timeline based on the four PAL PD training workshops and the collected documents to understand the temporal dimension of the implementation efforts. All REMs are recorded on video to reconstruct statements from participants not documented during the mapping.

Semi-structured interviews

Semi-structured interviews with key stakeholders (PALs, principals, and other members of the PA committee if necessary) will be conducted following the REMs to gain a deeper understanding of the decisions, activities, successes, and challenges within the support and delivery systems of the experimental schools. Analogous to Stimulated Recall Interviews, which use video or audio recordings as a starting point to stimulate reflections and considerations of the interviewee, the process mapping from the REM is intended to serve the interviewees as a memory aid and, at the same time, prevent statements from being influenced by social desirability [91]. The interviews aim to gain a deeper understanding of what was implemented and how the implementation of *Active School* was planned and executed in both support and delivery systems (dose of delivery). This includes identifying which interest groups were reached by the applied strategies in the support and delivery systems, assessing the feasibility from the perspective of these stakeholders, and determining the sustainability of the implementation throughout the project duration. Furthermore, the investigation aims to examine the extent to which determinants such as context, provider, program characteristics, and characteristics of the program delivery and support systems either support or hinder the successful implementation. The interview guides are grounded in theory, drawing from implementation theory [47]. However, the interview guidelines will be refined iteratively based on project developments and previously collected data.

Data analysis

Due to the low risk, no Data Monitoring Committee was formed. Data will be stored utilizing Cloud Databases, overseen by the research team. Electronic data will be exclusively stored in the Cloud Databases, whereas physical data will be stored securely in locked cabinets and later transcribed electronically. The research team regularly monitors data and performs interim analyses to check data quality. In adverse events, the relevant information is recorded; reviews and inspections are not planned, and access to the original documents is possible for independent auditors/inspectors and the Ethics Commission.

Effectiveness evaluation

Data analyses will be conducted using SPSS version 28.0 (IBM Corp., Armonk, NY, USA).

The primary analysis aims to investigate whether there is a higher level of objectively measured MVPA at the post (12 months) and follow-up assessment (24 months) in the experimental group compared to the waiting control group. Therefore, we will use linear mixed models

with standard errors adjusted for clustering and MVPA as the outcome variable. Changes in secondary outcomes (inactivity, light physical activity, step counts, aerobic fitness, coordination, self-reported physical activity, subjective wellbeing, classroom climate, school wellbeing, and learning behavior) will be examined as secondary analyses using the same strategy with linear mixed models. Exploration of changes in MVPA will be conducted by expanding the multilevel model to examine whether alterations are moderated by measured individual- or school-level characteristics. Therefore, we will examine the potential moderating effects of individual- (physical self-concept and motivation for exercise), class- (e.g., level, size) and school-level characteristics (physical activity environment in school) on student outcomes.

Additionally, we will investigate significant interaction terms by assessing subgroup variations in the primary outcome and selected secondary outcomes. Linear mixed models will be utilized to examine potential mediating processes, and the estimation of mediating effects will involve the use of a cluster-bootstrapped based product-of-coefficients test specifically designed for cluster RCTs. Multiple imputation methods will be used to address missing data. As part of our sensitivity analysis, we plan to replicate the analysis using both an intention-to-treat approach and a per-protocol approach. For intention-to-treat analyses, we will address missing data by employing multiple imputation methods. The per-protocol analysis will focus solely on participants who strictly adhered to the protocol and attended all follow-up visits. Effect sizes will be assessed to illustrate the magnitude of differences between the groups, and all tests will be two-sided with *p*-values reported accordingly. The estimates will be provided along with 95% confidence intervals.

Process evaluation

To investigate the process outcomes, quantitative data from the questionnaires and qualitative data, including documents, REMs, and semi-structured interviews, are included. Quantitative data gathered from the questionnaires completed by principals, PALs, and teachers will be condensed through descriptive statistics. The principal and PAL questionnaires will depict the school context, provider characteristics, and delivery and support system characteristics. The teacher questionnaire will be used to investigate teacher characteristics and project-specific items. Qualitative data, including all documents authored by the PA committee, the REMs, and the semi-structured interviews, will be analyzed using a framework approach [92]. We align our implementation outcomes with the model by McKay et al. [46], while our approach to analyzing implementation determinants is based on the framework for effective implementation by Durlak et al. [47]. Additional categories emerging during the analysis process will be derived inductively. The MAXQDA software is used for coding all qualitative data and content analysis [93]. This software provides comprehensive features for integrating qualitative and quantitative data to explore causal links between process determinants and outcomes.

Discussion

Swiss adolescents exhibit low physical activity levels [3] despite the recognized physiological and psychological advantages [7, 8]. The existing empirical evidence indicates that comprehensive school-based physical activity programs, positively impact adolescents' physical activity levels [28, 29]. They have the advantage that schools can adapt the promotion of physical activity to their conditions and needs, thereby contributing to greater sustainability of program's effectiveness [19]. As such programs currently don't exist in Switzerland, the purpose of this study is to implement and evaluate the impact of *Active School*, a Swiss comprehensive school-based physical activity program for secondary school. However, PAL which play a central role in the implementation of *Active School*, face numerous challenges due to this comprehensive school-based approach. Therefore, the intervention of *Active School* consists of a specific PD training program that aims to optimally support the PAL during the implementation and to prepare them to overcome the challenges, which altogether should lead to a positive impact on students' physical activity. This study's strengths lie in the parallel evaluation of both the effectiveness and process and the utilization of an objective measure of students' physical activity as the primary outcome. The outcomes of this study will furnish valuable insights into the implementation process and the effectiveness of *Active School.* Additionally, the study will provide new insights into how a CSPAP approach can be applied in Switzerland to enhance physical activity among Swiss adolescents.

Abbreviations

BMI	Body mass index
CS	Waiting control school
CSPAP	Comprehensive School Physical Activity Program
EE	Effectiveness evaluation
ES	Experimental school
ICC	Intraclass correlation coefficient
IP	Implementation phase
MVPA	Moderate-to-vigorous physical activity
PA	Physical activity
PAL	Physical activity leader
PD	Professional development
PE	Process evaluation
PP	Preparation phase
RCT	Randomized controlled trial
REM	Ripple effect mapping
WHO	World Health Organization

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Authors' contributions
SV, FE, and MS conceptualized the study and secured funding for the project. AN, MG, FE, SV, MK, and MS jointly conceptualized the intervention concept. MG, AN, FE, SV, MK, and MS collaboratively developed the project's evaluation design. AN, MG, FE, SV, MK, and MS are all members of the project team. AN and MG drafted the study protocol manuscript. All co-authors revised the work critically for important intellectual content and approved the final version of the manuscript.

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Availability of data and materials
The materials used during the planned project will be made available by the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
Active School has been approved by the Ethics Commission of the Faculty of Human Sciences at the University of Bern, Switzerland (Ref: 2023–03-05). Significant modifications to the study protocol will be communicated to pertinent stakeholders. To obtain the consent of the students for the effectiveness evaluation, the research team personally informs each class about the project. Subsequently, an information letter, including a consent form, is provided to take home. The form allows separate consent for participation in accelerometry, the aerobic fitness and coordination test, and the student questionnaire. As the students are not of legal age, the form must be signed by the parents and returned to the teacher within two weeks. The teacher then forwards the completed forms to the research team. The consent form explicitly includes the child's perspective in the consent statement. This ensures that both parental consent and the child's comprehension and willingness to participate are acknowledged and properly documented. To treat participants' data confidentially, each participant will be assigned an individually chosen participant code, which will be used for data collection purposes. For the process evaluation, written consent is additionally requested from the school principals, PALs, and teachers. This consent indicates their willingness to participate in one or more of the following methods: questionnaires, document analysis, REM, and interviews. All participants also have the right to withdraw from the study at any time at their discretion.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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