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Maintaining conceptual fidelity through teacher-led adaptation: an implementation-focused mixed methods study of a school-based physical activity program

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Abstract

Background School-based physical activity programs are widely promoted to address adolescent physical inactivity, yet their population-level impact is often limited by implementation challenges in real-world school settings. While implementation fidelity is frequently assessed, less is known about how teachers actively balance adherence and local adaptation while maintaining core program principles. This study examined the implementation of the FIT FIRST Teen (FFTeen) program in Danish lower secondary schools, with a particular focus on how conceptual fidelity was enacted through teacher-led adaptations.

Methods An implementation-focused mixed methods study was conducted in six intervention schools participating in a cluster randomized trial. Implementation fidelity was assessed through systematic observations of FFTeen sessions at three time points using a structured fidelity framework. Semi-structured interviews with teachers explored adoption, implementation experiences, adaptations, and perceived outcomes, guided by Rogers' Diffusion of Innovation theory. Data were analyzed using a deductive, framework-based approach integrating observational and interview data.

Results FFTeen was implemented with moderate to high fidelity across schools, although procedural adherence varied substantially. Teachers frequently adapted session structure, activities, and organization in response to contextual constraints such as facilities, class composition, and scheduling. These adaptations generally preserved the program's core principles of high intensity, inclusion, and enjoyment and were often associated with high student engagement. Teachers perceived FFTeen as offering clear pedagogical advantages over existing practices, particularly for engaging less-active students. However, sustained delivery of three weekly sessions was constrained by rigid timetables, competing curricular demands, and leadership support.

Conclusions This study demonstrates how conceptual fidelity in school-based physical activity programs can be maintained through teacher-led adaptation rather than strict procedural adherence. Findings highlight

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the importance of flexible program design, professional judgement, and organizational alignment when implementing scalable physical activity interventions in schools. Rather than viewing adaptation as a threat to fidelity, implementation strategies should support teachers in enacting core principles within diverse and resource-constrained school contexts.

Keywords Implementation, Physical activity, Schools, Fidelity, Diffusion of innovations

Background

Physical inactivity among adolescents is a major public health concern, with well-documented implications for physical and mental health across the life course, as well as substantial societal and economic costs [1]. Global guidelines recommend that adolescents accumulate at least 60 min of moderate-to-vigorous physical activity (MVPA) daily [2], yet approximately 81% of adolescents worldwide do not meet these recommendations [3]. In Denmark, only 27–33% of children and adolescents achieve the recommended levels of physical activity (PA) [4]. Because PA behaviors established during adolescence tend to persist into adulthood [5], effective strategies to promote PA at population level remain a public health priority.

Schools are widely recognized as key settings for delivering PA interventions at scale due to their reach and potential to reduce social inequalities in health [6, 7]. However, evidence from systematic reviews indicates that many school-based PA interventions achieve only modest and highly variable effects [8, 9]. Growing consensus suggests that limited effectiveness is often not a consequence of intervention content alone, but reflects challenges related to implementation under real-world school conditions, including competing curricular demands, limited time and facilities, and variable organizational support [6, 10, 11]. From a public health perspective, understanding how interventions are implemented in practice is therefore essential for informing scalability and sustainable population-level impact.

Implementation research offers frameworks to examine how interventions are adopted, delivered, and sustained across diverse contexts. The Consolidated Framework for Implementation Research (CFIR) highlights how intervention characteristics, organizational context, and implementation processes interact to shape delivery [12]. In school-based PA research, Rogers' Diffusion of Innovation theory has been widely applied to understand teachers' adoption and use of new practices, emphasizing attributes such as relative advantage, compatibility, complexity, trialability, and observability [13–15]. These attributes are particularly relevant in school systems, where teachers' everyday decisions directly influence whether and how interventions are enacted.

Implementation fidelity is commonly examined in evaluations of school-based PA interventions, yet fidelity is increasingly recognized as a multidimensional construct [16]. Procedural fidelity refers to the extent to which prescribed activities are delivered as specified in intervention manuals [17]. In contrast, conceptual fidelity refers to the extent to which the core principles and hypothesized mechanisms of impact are preserved in practice, even when surface-level adaptations occur [18, 19]. In the context of school-based PA interventions, these mechanisms may include delivering sufficient intensity, fostering inclusive participation, and promoting enjoyment to support sustained engagement in MVPA. Distinguishing between procedural and conceptual fidelity is particularly important in complex school environments, where adaptation may be necessary to accommodate contextual constraints while maintaining the intervention's intended function [18, 19].

Teachers routinely adapt intervention activities to accommodate contextual constraints, including class composition, space, equipment, and scheduling. Although such adaptations are often viewed as threats to fidelity, emerging evidence suggests that purposeful, teacher-led adaptation may enhance feasibility, engagement, and inclusivity, thereby supporting implementation quality in real-world settings [11, 18]. However, empirical studies that integrate systematic observations of delivery with teachers' perspectives to examine how conceptual fidelity is enacted in everyday school practice remain relatively limited, particularly within large-scale PA interventions. Stylianou et al. [20] demonstrated that teachers varied substantially in their fidelity to a physical education (PE) curricular model, with differences in enactment influencing PA levels, highlighting how variation in delivery can shape outcomes. Moreover, Walker et al. [21] combined implementation observations with qualitative interviews from school staff to examine how classroom-based PA approaches were supported and enacted in practice, underscoring the value of integrating delivery data with teachers' perspectives. Together, such studies emphasize the importance of examining how teachers interpret and operationalize program components in real-world contexts. Although this line of inquiry has begun to develop, the use of observational and qualitative data to examine how core principles are sustained over time remains comparatively underexplored, particularly in secondary schools. Further empirical work adopting such integrative approaches is therefore warranted.

The FIT FIRST Teen (FFTeen) program was developed as a school-based high-intensity PA intervention

targeting adolescents aged 12–15 years, with the aim of supporting regular participation in MVPA through short, structured sessions emphasizing inclusion, enjoyment, and high intensity. The program aligns with national PE curricula while allowing flexibility in scheduling and delivery to accommodate diverse school contexts. An initial 10-week efficacy trial demonstrated limited effects [22], highlighting the need to better understand how the program was implemented in practice and whether variation in delivery may have influenced outcomes. Building on this work, a larger effectiveness trial was initiated to evaluate health-related outcomes alongside real-world implementation across schools.

The aim of this study was to advance public health-relevant knowledge on the implementation of school-based PA interventions by examining how the FFTeen program was enacted in lower secondary schools under real-world conditions. Specifically, the study examined (1) how implementation fidelity was enacted and negotiated through teacher-led adaptations, and (2) how teachers' perceptions of adoption and implementation – interpreted through Rogers' Diffusion of Innovation attributes – related to observed delivery practice.

Methods

This study employed an implementation-focused, mixed methods approach to examine how the FFTeen program was delivered in real-world lower secondary school setting. The study was conducted alongside a cluster randomized controlled trial evaluating the effectiveness of FFTeen. The present study focuses on implementation fidelity, teacher-led adaptation, and adoption-related experiences during the intervention period.

The study was conducted and reported in accordance with the Standards for Reporting Implementation Studies (StaRI) statement [23], supporting transparent reporting of implementation-related methods and findings.

The FIT FIRST teen program

FFTeen is a school-based PA program designed to promote regular participation in high-intensity PA among adolescents aged 12–15 years. The program comprises 135 session plans across 24 sports, with each session lasting approximately 40 min. Sessions are guided by three core principles: high intensity, inclusion, and enjoyment. Teachers are encouraged to deliver three sessions per week on separate days to ensure regular exposure to MVPA.

The program is designed to align with Danish PE curriculum and national PA guidelines while allowing flexibility in how sessions are scheduled and delivered. FFTeen sessions can be implemented within PE lessons or integrated into other subject areas, depending on local timetables and organizational structures. In Denmark, PE is a compulsory subject within the national curriculum, and lower secondary schools typically allocate two weekly PE lessons. Although national health guidelines recommend that children and adolescents accumulate at least 60 min of MVPA daily [24], there is no specific policy requirement for schools to provide this amount within the school dat. Within this structural context, implementing three FFTeen sessions per week may therefore require timetable adjustments or cross-curricular integration (e.g., Danish or mathematics).

To accommodate diverse school contexts, session plans were developed with built-in flexibility. While some activities required access to a sports hall and equipment, many sessions could be conducted in classrooms, schoolyards, or outdoor environments, enabling implementation even in settings with limited facilities. This flexibility was intentionally incorporated into the program design to enhance feasibility and scalability across schools with varying organizational capacities, while maintaining the program's core principles.

The FFTen program was developed collaboratively by researcher from the University of Southern Denmark, the Danish Sports Confederation, Team Denmark, and representatives from multiple national sport federations. The program is intended to be accessible to teachers with varying professional backgrounds, including those without formal PE training, thereby supporting broad applicability across diverse school settings.

A detailed description of the FFTeen intervention structured according to the TIDieR checklist is provided in Supplementary File 1 [25].

Implementation support

To support implementation, teachers and school staff from intervention schools participated in a one-day, in-person training course delivered by members of the FIT FIRST FOR ALL project team, often in collaboration with representatives from relevant sports federations. The training was designed to enhance teachers' knowledge, skills, and confidence in delivering FFTeen, while emphasizing flexibility and professional judgement rather than strict procedural adherence.

The training consisted of both theoretical and practical components. The theoretical component introduced the scientific rationale underlying the FIT FIRST program and elaborated on how the three core principles – high intensity, inclusion, and enjoyment – should guide delivery across different activities and contexts. The practical component was conducted in a sports hall and included hands-on participation in selected FFTeen activities. Teachers were introduced to the structure and progression of sessions and engaged in reflective discussions on how activities could be adapted to accommodate variations in facilities, class composition, and student needs.

Throughout the training, instructors used reflective questioning to encourage participants to consider potential implementation challenges and solutions within their own school contexts. The training concluded with structured discussions on strategies for integrating FFTeen sessions into existing timetables, including delivery within and beyond PE lessons.

All participating teachers received a comprehensive manual containing detailed session plan and guidance for the 24 sports included in the program. In addition, intervention schools were provided with essential equipment (e.g., balls, cones, scrimmage vests) to facilitate program delivery. Ongoing informal support was available from the project team during the intervention period as needed.

Table 1 Overview of implementation fidelity dimensions included in the observation guide, adapted from Carroll et al. [19]

Dimension	Definition	Observational data
Adherence	The extent to which FFTeen was delivered as intended, including following activities from the manual. Adaptations made, their purpose, and their impact on activities.	Percentage, using five-point scale (0%, 25%, 50%, 75%, or 100%) and qualitative notes
Dose delivered/ exposure	The duration of each FFTeen session.	Minutes Qualitative notes
Dose received/ coverage	The proportion of students who participated in the FFTeen activities.	Percentage
Quality	The quality of the activities delivered. The degree to which sessions adhered to FFTeen's guiding principles and were delivered smoothly, ensuring flow, engagement, and effective management of time and participation.	Grading (high/ medium/low) Qualitative notes
Participant responsiveness	The participants' engagement in the activity, including their active participation throughout each session.	Qualitative notes
Program differentiation	The key elements or components of the program that appeared to have a significant impact on FFTeen principles.	Qualitative notes
Intervention complexity	The participants' ability to initiate and carry out the activity as intended without additional explanation.	Grading (high/medium/low) and qualitative notes
Facilitation strategies	The strategies used to optimize fidelity in each session.	Qualitative notes

Study setting and participants

The FFTeen trial included public and private lower secondary schools across Denmark. Schools were recruited between October 2023 and June 2024 through national and regional outreach channels, including professional networks, online announcements, and direct contact. A total of 24 schools were recruited and randomly allocated to either the intervention or control group.

Six intervention schools were purposively selected prior to baseline testing to participate in the implementation study. Selection criteria aimed to ensure variation in geographical location (eastern and western Denmark), school size, and school type (public/private), thereby capturing diverse implementation contexts. Within each selected school, one class and the responsible teacher were included in the implementation study. In some schools, only one class participated in the intervention, meaning no further selection was required. In schools with multiple classes, a class scheduled to implement FFTeen was identified in collaboration with the participating teachers from that school. The same class and teacher were followed across observation time points.

Teachers represented varying professional backgrounds, including both those with formal PE training and those without specialist PE qualifications. Information regarding teachers' professional background was obtained through interview accounts and contextual information during observations rather than through structured demographic data collection.

Data collection

Implementation was examined using two complementary qualitative data sources: systematic observations of FFTeen sessions and semi-structured interviews with teachers. Data collection was designed to capture both enacted delivery practices and teachers' perspectives on adoption, adaptation, and feasibility.

Systematic observations

One class per school was observed at three time points during the intervention period (early, mid and late implementation), except where logistical constraints prevented all observations.

Observations were conducted by the first author using a structured observation guide informed by Carroll et al.'s conceptual framework for implementation fidelity (see Supplementary file 2) [19]. Observations captured multiple dimensions of implementation, including adherence to planned activities, adaptations, session duration, student participation, quality of delivery, participant responsiveness, program differentiation, intervention complexity, and facilitation strategies (see Table 1). Quantitative rating (e.g. high/medium/low) were combined

with detailed qualitative field notes to document how sessions were enacted in practice.

The degree of deviation from the FFTeen manual was assessed by the first author, who conducted all observations. Classification was based on the proportion of prescribed FFTeen activities completed during each session, as documented using the structured observation guide. Adherence categorized into five levels based on predefined percentage thresholds (0%, 25%, 50%, 75%, and 100%) reflecting the degree of deviation from the FFTeen manual. These thresholds corresponded to minimal (0%), low (25%), medium (50%), high (75%), and complete adherence (100%). This percentage-based approach provided a consistent and transparent basis for categorization across sessions.

Adaptations were similarly categorized based on the degree of deviation from the manual; minor modifications (e.g., small adjustments for space or equipment) were considered as high adherence, moderate modifications (e.g. changes to group composition or activity sequence) as medium adherence, and major modifications (e.g., substantial alteration of activity structure or core principles) as low adherence. Finally, sessions where all content was modified (e.g., none of the activities adhered to FIT FIRST content or the guiding principles) were categorized as minimal adherence. Adapted sessions were classified as high fidelity when modifications did not alter the program's core principles or hypothesized mechanisms of impact – namely high intensity, inclusion, and enjoyment – but instead reflected contextual adjustments necessary for local implementation. This operationalization was informed by the distinction between procedural and conceptual fidelity [18, 19]. Determining whether adaptations preserved core principles involves interpretive and normative judgement. To enhance transparency and consistency, predefined criteria were applied systematically across observations.

Table 2 Overview of the key adoption and implementation attributes adopted from Rogers [12] informing the interview guide

Dimension	Definition
Relative advantage	The perceived benefits of the FFTeen program compared to existing PA practices.
Compatibility	The degree to which FFTeen fits with teachers' existing values, school culture, and current routines.
Complexity	The perceived difficulty of the program for teachers and students in terms of understanding, delivering, and participating in the activities.
Trialability	The extent to which teachers were able to experiment with and test FFTeen sessions on a limited basis, allowing them to try out elements of the program and adjust them to their school context during implementation.
Observability	The visibility of FFTeen's effects, including noticeable improvements in student participation, enjoyment, and fitness.

Dose was differentiated into dose delivered and dose received. Dose delivered (exposure) referred to the duration of each FFTeen session (i.e., session length in minutes). Dose received (coverage) referred to the proportion of students who participated in the session, operationalized as the percentage of students actively engaged in the activities. This distinction allowed to differentiate between the amount of intervention delivered and the extent to which students were exposed to and participated in the activities. Quality captured delivery clarity, class management, and adherence to guiding principles (enjoyment, inclusion, high intensity). Participant responsiveness reflected study engagement. Program differentiation highlighted elements supporting core principles. Complexity was graded based on required teacher support and scaffolding. Facilitation strategies included teacher actions to support fidelity. Observation notes were conducted using the protocol guided by Carroll et al. [19] to ensure reliability and comparability across time points.

Teacher interviews

Semi-structured interviews were conducted with the teachers responsible for the observed classes at two time points (early and late in the intervention period). The interview guide was informed by Rogers' Diffusion of Innovation theory [13] and focused on teachers' perceptions of relative advantage, compatibility, complexity, trialability, and observability of the FFTeen program (see Table 2 and Supplementary file 3 and 4).

Interviews explored teachers' experiences with implementing FFTeen, perceived benefits and challenges, adaptations made during delivery, and reflections on feasibility and sustainability. Interviews were conducted in early autumn 2024 and again in late spring 2025. Interviews were conducted in Danish and lasted between 16 and 40 min (mean duration: 25 min). All interviews were audio-recorded and transcribed verbatim in Danish. Coding was conducted using the original Danish transcripts to preserve meaning. Quotations included in the manuscript were translated into English during the manuscript preparation, with attention to retaining conceptual meaning rather than literal phrasing.

Data analysis

Observation notes and interview transcripts were imported into NVivo (version 15) for data management and analysis. Data were analyzed using a primarily deductive, framework-based approach [26, 27] explicitly guided by Carroll et al.'s Conceptual Framework for Implementation Fidelity [19] and Rogers' Diffusion of Innovation Theory [13].

Observational data were coded according to the dimensions outlined in Carroll et al.'s framework, including

adherence, dose (delivered/exposure and received/coverage), quality of delivery, participant responsiveness, intervention complexity, and facilitation strategies [19]. These constructs served as the primary analytic categories through which enacted delivery practices were examined.

Interview data were analyzed using constructs from Rogers' Diffusion of Innovation attributes – relative advantage, compatibility, complexity, trialability, and observability – as sensitizing constructs to explore teachers' perceptions of adoption and implementation [13].

A structured coding framework was developed a priori based directly on these theoretical models. While the overall analytic structure was deductive, data within each predefined category were coded inductively to capture contextual nuance in how fidelity dimensions and diffusion attributes were expressed in practice. No additional overarching themes outside the guiding theoretical frameworks were identified.

Observation and interview data were initially coded separately to preserve the distinct perspectives captured by each data source. Coding was conducted iteratively by the first author, who reviewed transcripts and observation notes multiple times to ensure familiarity with the data. To retain original meaning during data reduction, coding was conducted close to participants' language, and analytic memos were used to document contextual interpretations and analytic decisions.

Following coding, data were organized using the framework method, enabling systematic comparison across schools and observation time points. Framework matrices preserved explicit links to original data excerpt to maintain transparency between raw data and interpretive synthesis. Observational and interview data were subsequently integrated during the interpretive phase to examine convergence and divergence between enacted delivery practices and teachers' reported experiences.

Although coding was conducted by the first author, predefined coding criteria, systematic documentation, and iterative review supported consistency across cases and time points. The analysis was descriptive and interpretive in nature, aiming to identify empirically grounded patterns in implementation rather than test hypotheses or quantify relationships.

Ethics approval and consent to participate

The study received a waiver from the Health Research Ethics Committee of the Region of Southern Denmark (S-20222000–221108). In accordance with Danish law (§ 14, stk. 2), only health research projects involving interventions on human beings, biological material, or clinical trials require formal approval from a regional ethics committee. As the present study involved non-invasive observations and interviews with teachers and did not include any collection of biological material or health-related interventions, it did not fall within the scope of projects requiring ethics committee approval.

The study was additionally approved by the legal service department at the University of Southern Denmark (11.806) and conducted in accordance with the principles of the World Medical Association Declaration of Helsinki. Observation notes and interview transcripts were anonymized, and no personally identifiable information was collected. Written informed consent was obtained from teachers participating in the observations and interviews prior to data collection.

Results

Fidelity

All classes were observed three times (early, mid, and late implementation), except for two classes that were observed twice due to logistical challenges. Table 3 summarizes observational data on adherence, dose, quality, coverage, and complexity. Across schools and time points, substantial variation in implementation was observed.

Although schools differed in geographical location, school type, and size, contextual variation appeared to play a limited role in shaping overall implementation patterns. The most consistent contextual influence concerned facility access, particularly in urban school with restricted space, which required more frequent spatial adaptations. Other structural differences did not appear to substantially influence fidelity or adaptation patterns.

Adherence ranged from 0% (fully adapted sessions) to 100% (no adaptation). Adaptations included gender-based groupings and adjustments related to teacher experience, available space, or equipment. Session dose ranged from 30 to 60 min, reflecting scheduling constraints as well as occasions where high-intensity activities were extended. Coverage was generally high, with most students actively participating across sessions.

Quality of delivery varied across schools. Inclusion was rated as high in 81.3% of sessions, medium in 12.5%, and low in 6.2%. High-intensity activities was rated as high in 37.5% of sessions, medium in 43.7%, and low in 18.8%, while enjoyment was rated as high in 68.8% and medium in 31.2% of sessions, with no sessions rated as low. Inter-school differences included consistently high inclusion in Schools C, D, and F, and lower inclusion in School B at T2. In several schools, intensity increased over time, whereas enjoyment remained consistently medium to high across sessions.

Intervention complexity was generally rated as low to moderate. Most students were able to perform activities with minimal instruction once familiar with the session format. However, new or less structured activities required additional teacher guidance and scaffolding.

Table 3 Observed implementation fidelity of FFTeen sessions across schools and timepoints (T1, T2, T3)

	Adherence	Dosage/ exposure	Coverage	Quality	Intervention complexity
School A T1	0% adherence, 100% adaptations*	30 min	All students participated (100%)	Inclusion: high Intensity: low Enjoyment: medium	Low
T2	50% adherence 50% adaptations	35 min	All students participated (100%)	Inclusion: high Intensity: medium Enjoyment: high	Low
T3	75% adherence 25% adaptations	30 min	All students participated (100%)	Inclusion: medium Intensity: medium Enjoyment: medium	Medium
School B T1	100% adherence	60 min	Most students participated (90%)	Inclusion: medium Intensity: medium Enjoyment: medium	Medium
T2	0% adherence 100% adaptations**	45 min	More than half of the students participated (60%)	Inclusion: low Intensity: low Enjoyment: high	Low
T3***	-	-	-	-	-
School C T1	0% adherence, 100% adaptations*	30 min	Almost all students participated (95%)	Inclusion: high Intensity: high Enjoyment: high	Low
T2	100% adherence	40 min	All students participated (100%)	Inclusion: high Intensity: medium Enjoyment: high	Low
T3	100% adherence	45 min	Almost all students participated (95%)	Inclusion: high Intensity: high Enjoyment: high	Medium
School D T1	100% adherence	50 min	Almost all students participated (95%)	Inclusion: high Intensity: high Enjoyment: high	Low
T2	75% adherence 25% adaptations	55 min	Almost all students participated (95%)	Inclusion: high Intensity: high Enjoyment: high	Low
T3***	-	-	-	-	-
School E T1	50% adherence 50% adaptations	40 min	All students participated (100%)	Inclusion: high Intensity: low Enjoyment: medium	Medium
T2	100% adherence 0% adaptations	50 min	All students participated (100%)	Inclusion: high Intensity: medium Enjoyment: medium	Low
T3	100% adherence 0% adaptations	50 min	All students participated (100%)	Inclusion: high Intensity: medium Enjoyment: high	Medium
School F T1	100% adherence	45 min	All students participated (100%)	Inclusion: high Intensity: medium Enjoyment: high	Low
T2	100% adherence	45 min	All students participated (100%)	Inclusion: high Intensity: high Enjoyment: high	Low
T3	100% adherence	35 min	Almost all students participated (95%)	Inclusion: high Intensity: high Enjoyment: high	Low

* Teachers received the manual on the day for observation and did not have the opportunity to prepare FIT FIRST activities in advance

** At this school, the decision was made to separate boys and girls and implement FIT FIRST separately for each group, primarily to enhance motivation among the girls

***This class was observed only twice due to logistical challenges (e.g., cancelled sessions because of field trips)

Student engagement, as reflected in qualitative observations of enthusiasm, effort, and interaction, ranged from low (minimal visible involvement despite attendance) to high (enthusiastic and fully involved participation), although quantitative coverage (i.e., proportion of students participating) was generally 60& or higher across sessions.

Program differentiation referred to specific FFTeen activity types and structures that appeared to support the program's core principles of high intensity, inclusion, and enjoyment. In particular, activities characterized by clear rules, short work-rest intervals, and collaborative or structured competitive formats were associated with higher student engagement and sustained intensity.

Facilitation strategies, including thorough preparation, clear instructions, stepwise demonstrations, active teacher involvement, structured pairing, use of music, and ongoing encouragement, further supported delivery of these activities and contributed to maintaining conceptual fidelity, particularly by sustaining high intensity, inclusion, and enjoyment during sessions.

Relative advantage

Interview data highlighted teachers' perceptions of FFTeen's relative advantages in everyday teaching. Teachers consistently emphasized the program's ability to engage and motivate students through brief, high-intensity activities, which facilitated focus and reduced complaints:

> *"What has been particularly effective is the high-intensity, short-duration format… students fully engaged and hardly complain because the sessions are brief yet intense" (School D, late interview).*

Another frequently mentioned advantage was the inclusive structure of activities, which enabled meaningful participation across student ability levels. Structured partner work and varied activity formats were perceived to reduce competitiveness:

> *"Because it is a scaffolded activity, with partner and simple instructions, competition does not dominate… especially when partners are boy/girl pairings or highly active students are paired with less active ones" (School E, early interview).*

Teachers further described broader socio-emotional benefits associated with FFTeen, including enhanced social interaction and confidence. The program was perceived as offering meaningful learning experiences without academic pressure: *"…It benefits them personally and socially, showing huge potential for the educational and developmental mission of our schools"* (School C, early interview). Observations supported these perceptions, indicating that when teachers adapted activities, student engagement remained high, with pairing, games, and varied formats sustaining intensity, enjoyment, and inclusion.

Compatibility

FFTeen was generally perceived as compatible with schools' existing structures, resources, and pedagogical approaches. However, successful integration depended on leadership support, timetable flexibility, and resource availability. Teachers often described the need to adjust or deprioritize other activities to accommodate FFTeen sessions:

> *"Yes, you have to give up something… the biggest challenge is with academic subjects, as they feel time is taken away from their lessons" (School A, early interview).*

Facilities and logistical resources further influenced compatibility. Access to gym halls or indoor and outdoor areas facilitated implementation, while pre-booked facilities, renovations, or limited equipment required creative adaptations. With regard to sessions delivered outside PE, one teacher explained:

> *"We have the facilities (for the FFTeen sessions) … and because we could plan far in advance, we fit it into the timetables. Otherwise, it would have been problematic" (School C, late interview).*

Observations confirmed that teachers adjusted activities to fit available space and resources, often using modified setups without compromising the program's three core principles. Teacher engagement also influenced implementation. In schools relying on a small number of highly motivated 'champions', sustaining momentum was challenging when leadership support was limited:

> *"We don't have leadership that is very interested… it would have been great to have more attentive leadership" (School C, early interview).*

Overall, FFTeen was perceived as compatible with school culture when leadership was supportive, timetables were sufficiently flexible to allow teachers control over scheduling, and resources were adequate.

Complexity

FFTeen was generally perceived as low to moderate in complexity, with successful implementation depending on teachers' prior experience with PE. Based on interviews, teachers with formal PE training described

the activities as easier to implement, whereas teachers without specialist PE qualifications reported requiring additional guidance or repeated exposure to become confident using the manual. Nevertheless, the FFTeen manual was generally valued as a supportive resource, particularly among non-PE teachers, as it reduced uncertainty through clear, step-by-step instructions and allowed flexibility in selecting and adapting activities to local contexts. However, some activities were perceived as difficult to interpret without prior experience.

> *"It's easy for those with experience. Less experienced teachers may need to simplify activities and may struggle to understand the manual fully" (School F, late interview).*

Practical constraints further increased perceived complexity. Equipment availability, class size, and space limitations required adaptations such as splitting classes, modifying indoor setups, or postponing sessions. Overall, FFTeen was manageable with adequate preparation, flexibility, and teacher engagement. Perceived complexity primarily stemmed from resource limitations, planning demands, unfamiliar activities, space constraints rather than from the program design itself.

Trialability

FFTeen was perceived as easy for teachers to try out on small steps, allowing experimentation before full integration into everyday teaching. Teachers described how they initially incorporated selected FFTeen activities into their regular PE lessons while maintaining elements of their usual teaching routines. Over time, those teachers gradually increased the proportion of FFTeen activities within lessons, moving from using one or two activities per lesson to delivering full FFTeen sessions. This stepwise integration supported familiarization with the program and contributed to growing confidence in delivery.

Teachers frequently adjusted sessions to accommodate practical circumstances such as limited facilities or varying student needs. These adaptations were generally described as part of the process of trying out activities to determine what worked best in specific classroom contexts. Observations confirmed that students responded positively when teachers experimented with different formats. Offering variation, choice, and playful elements supported engagement, even during repetitive activities: *"We ended with a game to maintain motivation and provide a 'carrot' for the session"* (School C, late interview).

Teachers also highlighted the flexibility to conduct activities in different settings as supporting trialability: *"We can use the schoolyard, the sports field, or the forest behind us… we have all opportunities for active teaching"* (School B, early interview).

Overall, the ability to experiment with FFTeen activities in a low-risk manner facilitated implementation by supporting teacher autonomy, enhancing student motivation, and enabling integration across diverse school contexts.

Observability

Teachers reported observable changes in student engagement, motivation, and participation during FFTeen sessions, particularly among students who were typically less active in PE. Increased enjoyment, enthusiasm, and willingness to participate were commonly described:

> *"Less experienced students discovered many activities were fun. One student who struggled initially has improved greatly and consistently reported enjoying the sessions. Many students enjoyed participating at their own level" (School F, late interview).*

Teachers noted that students frequently asked about upcoming FFTeen sessions and demonstrated eagerness to participate. Observations corroborated these accounts, showing that most students were engaged, collaborated effectively, and visibly enjoyed the activities, as reflected in laughter, social interaction, and sustained effort (see Table 3).

Although participant responsiveness varied according to prior experience, skill level, and gender, teachers actively employed adaptive strategies to support engagement. Structured pairing was used to foster peer support, teacher demonstrations clarified expectations, and small modifications to task difficulty or rules increased accessibility without compromising core principles. These adaptations contributed to observable improvements in student confidence, social interaction, and willingness to persist during sessions.

Discussion

This implementation-focused study examined how the FFTeen program was enacted in lower secondary schools under real-world conditions. By integrating systematic observations with teachers' perspectives, the study provides empirical insight into how implementation fidelity, adaptation, and feasibility interact in school-based PA programs. Overall, FFTeen was delivered with substantial procedural variation across schools, yet the program's core principles of high intensity, inclusion, and enjoyment were largely preserved. These findings highlight the importance of conceptual fidelity and teacher-led adaptation when implementing scalable PA interventions in complex school settings.

A detailed description of the FFTeen intervention components and delivery structure is provided in Supplementary File 1 (TIDieR checklist), supporting transparency

regarding the specific elements that were subject to adaptation across schools [25].

Enacting fidelity through adaptation to real-world school contexts

A central finding of this study was that variation in procedural adherence did not necessarily correspond to lower implementation quality. While FFTeen sessions were frequently adapted in response to contextual constraints such as facilities, scheduling, and class composition, these adaptations were often purposeful and aligned with the program's core principles. This supports previous work suggesting that strict procedural adherence may be neither feasible nor desirable in complex interventions delivered in schools [16, 18, 19].

Rather than viewing adaptation as deviation from intended delivery, the findings indicate that teacher-led adaptation functioned as a mechanism through which conceptual fidelity was enacted. Teachers adjusted activities, grouping, and organization to sustain intensity, inclusion, and student engagement, particularly among less-active students. This aligns with emerging implementation research emphasizing the distinction between fidelity to form and fidelity to function [18, 19], and extends this literature by providing empirical evidence from repeated classroom observations across diverse school contexts.

Program differentiation and facilitation as distinct contributors to fidelity

The study further contributes to implementation research by distinguishing between program differentiation and facilitation strategies as complementary but analytically distinct contributors to implementation fidelity. Program differentiation referred to characteristics of specific FFTeen activity types and structures that appeared to support the program's core principles, such as activities with clear rules, short work-rest intervals, and collaborative or structured competitive formats. These activity characteristics were consistently observed in sessions with higher engagement and sustained intensity across observed sessions.

In contrast, facilitation strategies – including clear instructions, demonstrations, structured pairing, encouragement, and use of music – related to how teachers supported the delivery of activities rather than to the content of the program itself. This distinction is rarely made explicit in school-based PA research, yet it has important implications for intervention design and scaling. While facilitation strategies may vary according to teacher experience and context, identifying program components that are inherently robust to contextual variation may support more sustainable implementation at scale [11, 18].

Adoption and feasibility from a public health perspective

Teachers' perceptions of FFTeen largely reflected positive assessment of relative advantage, compatibility, trialability, and observability, consistent with Rogers' Diffusion of Innovation theory [13]. The short, high-intensity session format was perceived as particularly advantageous, facilitating engagement without imposing excessive demands on time or student motivation. Importantly, teachers described observable benefits beyond PA, including social interaction and confidence, which may enhance acceptability and sustained use in school settings. Such experiences are previously shown to support physical literacy, enhancing confidence, motivation, and a positive relationship with movement [28], which also aligns with the SAAFE principles, emphasizing supportive and enjoyable environments as essential for both learning and sustained PA [29]. Interestingly, FFTeen shares features with international school-based sport programs. For example, Dudley et al. [30] systematically reviewed school sport and PE programs and found that structured, teacher-supported activities can effectively enhance student engagement, PA, and movement skills.

However, compatibility was strongly influenced by organizational conditions, particularly timetable flexibility, facility access, and leadership support. While teachers demonstrated considerable capacity to adapt delivery at the classroom level, structural constraints often limited the frequency and consistency of sessions. This finding echoes previous research highlighting the role of organizational readiness and leadership engagement in school-based implementation [6, 12]. From a public health perspective, these findings underscore that scalable interventions must be designed not only for pedagogical effectiveness but also for organizational feasibility within existing school systems [11].

Implication for scaling, research, policy, and practice

The findings suggest that scalable school-based PA interventions may benefit from explicitly distinguishing between core principles and adaptable delivery outcomes. Rather than attempting to minimize variation, implementation efforts may be strengthened by supporting structured flexibility, enabling teachers to adapt the form of delivery while preserving the intended function and mechanisms of impacts. This distinction between function and form has been highlighted as central to scaling complex interventions across diverse contexts [31]. From a public health perspective, such an approach may enhance both feasibility and sustainability in heterogeneous school environments.

From a research perspective, the findings underscore the value of articulating explicit program theories or logic models that link core intervention components

to hypothesized mechanisms of impact and associated implementation strategies. Contemporary guidance on complex interventions emphasizes the importance of making underlying assumptions and casual pathways explicit to support interpretation and transferability [18, 32]. While FFTeen was guided by clearly defined principles – high intensity, inclusion, and enjoyment – a formal logic model specifying how individual activities, teacher facilitation strategies, and contextual adaptations are expected to influence student engagement and MVPA could further support evaluation and scaling. Such an approach would also facilitate clearer differentiation between core components and adaptable elements, consistent with implementation frameworks that distinguish between core and peripheral features of interventions [12, 33].

From a policy perspective, the results highlight importance of aligning school-based PA initiatives with structural and organizational conditions, including facility access, timetables flexibility, and particularly leadership support as a system-level determinant shaping organizational readiness, prioritization, and sustainability [34]. Policies promoting PA in schools may therefore benefit from emphasizing conceptual clarity and supportive implementation conditions rather than rigid dosage requirements.

Practical implementation guidance emerging from these findings includes early leadership engagement, assessment of organizational readiness, structured preparation perios, and explicit clarification of core principles prior to rollout.

In addition, the findings underscore the importance of ensuring practice fit between the intervention and the organizational context in which it is delivered. Successful implementation may require sufficient lead-in time, assessment of organizational readiness, and active leadership support to facilitate scheduling, resources allocation, and prioritization within existing school structures. Preparing schools for implementation may therefore be as important as the intervention content itself.

For practice, the findings suggest that professional judgement and adaptive capacity among teachers should be recognized as central implementation resources. Training and implementation support strategies may be most effective when they clarify core principles and intended mechanisms while equipping teachers with the confidence to tailor delivery within their specific school contexts.

Methodological considerations

This study has several strengths that should be acknowledged. The use of repeated, systematic observations combined with teacher interviews allowed implementation to be examined over time from both enacted and perceived perspectives, in line with recommendations for studying complex interventions in real-world settings [16, 18, 35]. The application of established implementation frameworks supported analytic transparency and comparability with existing research [13, 19].

Several limitations are also important to consider. First, the study was conducted in a limited number of schools within a Danish context, which may influence the transferability of findings to other educational settings with different organizational structures, curricular demands, or policy contexts. However, the aim of the study was not statistical generalization but to identify implementation patterns and mechanisms that may be analytically transferable to similar school settings.

Second, although repeated observations strengthened understanding of implementation dynamics, the observational sample was restricted to one class per school. In some schools, only one class participated in the intervention, however, in schools with multiple intervention classes, one class was selected for participation in the implementation study. As participation required repeated observations and interviews, inclusion may have favored teachers who were more motivated to participate in research activities. This may introduce potential selection bias, as participating teachers may not fully represent all teachers delivering FFTeen across the intervention schools. Moreover, within-school variation may not be fully captured, particularly in schools where multiple teachers or classes implemented the program differently. Future studies could expand observational coverage to include multiple classes or teachers per school to better capture intra-organizational variation.

Third, while the study provides detailed insight into implementation processes, it did not examine direct associations between implementation fidelity and student-level health or organizational outcomes. As highlighted in guidance on complex intervention research, implementation and effectiveness are related but distinct components [18]. Further research is needed to examine how different patterns of conceptual fidelity relate to outcomes over time and across larger samples.

Fourth, data collection and analysis were primarily conducted by the first author, which may introduce potential observer and interpretive bias [36]. The first author's familiarity with the FFTeen program and background in PA research may have influenced attention to certain aspects of implementation during data generation and analysis. To mitigate this, structured a structured observation guide, predefined analytical frameworks, and systematic documentation were applied throughout the study. Interpretations were discussed within the research team to support reflexive consideration of emerging findings and to enhance analytic consistency.

Additionally, as with all observational research, the presence of a researcher during sessions may have influenced teacher and student behavior (i.e., reactivity or demand characteristics) [36]. Teachers may have demonstrated heightened adherence to core principles, and students may have exhibited increased engagement during observed sessions. Although repeated observations across time points were intended to reduce the impact of single-session reactivity, such influences cannot be entirely excluded.

Finally, the study relied primarily on teacher perspectives and observational data and did not include direct data collection from students. While participant responsiveness was assessed through systematic observation, incorporating student interviews or surveys could have provided additional insight into how adaptations were experienced and how they influenced perceived enjoyment, inclusion, and engagement. Including students perspectives may have strengthened triangulation and offered a more comprehensive understanding of how conceptual fidelity was enacted in practice. Thus, the findings should therefore be interpreted within the context of qualitative implementation inquiry rather than causal inference regarding intervention effectiveness.

Conclusion

This study suggests that school-based PA programs can be implemented with high conceptual fidelity under real-world conditions, despite substantial procedural variation. In the FFTeen program, teachers actively adapted session structure and organization in response to contextual constraints, while largely preserving the program's core principles of high intensity, inclusion, and enjoyment. Rather than undermining implementation quality, teacher-led adaptation functioned as a key mechanism enabling alignment between program intent and local school contexts.

By distinguishing between procedural adherence and conceptual fidelity, this study contributes implementation-relevant research on how structured flexibility supports enactment of complex interventions in schools. The findings suggest that clear guiding principles, combined with adaptable activity structures, allow teachers to exercise professional judgement without compromising the intended function of the intervention.

From a public health perspective, these results highlight that the scalability and sustainability of school-based PA programs depend not only on engaging content, but also on organizational alignment, leadership support, and professional autonomy. Interventions aiming for population-level impact should therefore prioritize conceptual clarity and structured flexibility rather than rigid delivery requirement, supporting teachers in enacting core principles within diverse and resource-constrained school systems.

Abbreviations

FFTeen	FIT FIRST Teen
PA	Physical activity
PE	Physical education

Supplementary Information

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Supplementary Material 1.

Supplementary Material 2.

Supplementary Material 3.

Supplementary Material 4.

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Declaration of generative AI and AI-assisted technologies

During the preparation of this work, the authors used ChatGPT (GPT-5 mini) in order to support language editing and proofreading. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the manuscript. The tool was not used for the generation of original content, data analysis, or interpretation of findings.

Authors' contributions

SK: Conceptualization, Investigation, Project administration, Writing – original draft. GT: Project administration, Writing – review & editing. NN: Funding acquisition, Writing – review & editing. CTN: Funding acquisition, Writing – review & editing. MNL: Funding acquisition, Writing – review & editing. PK: Funding acquisition, Project administration, Writing – review & editing. LBSC: Conceptualization, Funding acquisition, Supervision, Writing – review & editing.

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Data availability

The data supporting the conclusions of this article are available at the time of publication upon request. If approved by the Danish Data Protection Agency, data will be available.

Declarations

Competing interests

The authors declare no competing interests.

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