BMC Public Health

RESEARCH

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Web-based intervention program to foster need-supportive behaviors in physical education teachers and parents: a cluster-randomized controlled study to increase students' intention and effort to engage in physical activity

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Abstract

Background This study evaluates the effect of two web-based interventions– one targeting physical education (PE) teachers and the other targeting parents– designed to enhance need-supportive behaviors in their interactions with adolescents. Need support, which involves fostering autonomy, competence, and relatedness, plays a crucial role in increasing adolescents' autonomous motivation, intention, and effort in leisure-time physical activity (PA).

Methods 115 child-parent pairs were recruited (children: 55 boys, 60 girls; M_{age}=12.47, SD=0.68). Participants were cluster-randomized by schools into the following groups: PE teacher training only; parent training only; combined PE teacher and parent training; and control group. Data from students were collected at four time points: baseline, post-intervention, 1-month follow-up, and 6-month follow-up, using web-based questionnaires. The effects of the interventions on the study variables were assessed using path analysis.

Results The intervention for PE teachers had a significant direct effect on adolescents' perceived need-support from parents (β=0.28, p=0.027), controlled motivation in PE (β=-0.25, p=0.042), attitude towards (β=0.24, p=0.016), and perceived behavioral control regarding leisure-time PA (β=0.30, p=0.006). Changes in perceived need support from PE teachers enhanced students' autonomous motivation in PE (β=0.61, p=0.001), while need support from parents increased autonomous motivation towards leisure-time PA (β=0.29, p=0.041). Changes in perceived need-support from parents additionally had significant specific indirect effects on changes in adolescents' intention (B=0.06, p=0.025) and effort (B=0.04, p=0.024) towards leisure-time PA, the effect mediated by changes in autonomous motivation and attitude.

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Discussion While PE teachers' support is necessary in fostering autonomous motivation in students, parental support may need more tailored strategies. Both parents and PE teachers play a critical role in providing need support, which significantly enhances adolescents' motivation toward leisure-time PA. When adolescents feel supported, their attitude, intention, and effort toward leisure-time PA improve.

Conclusions Web-based intervention for PE teachers effectively changed motivational constructs, while the parental intervention did not yield expected direct effects, indicating that parental support may be more complex. This study emphasizes the role of perceived need support from PE teachers and parents in enhancing adolescents' autonomous motivation towards leisure-time PA, highlighting the need for collaboration between educators and parents in supporting adolescents' basic psychological needs.

Trial registration Prospectively registered in ISRCTN registry as ISRCTN78373974 (15.12.2022). Overall study status is 'completed'.

Keywords Children, Self-determination theory, Autonomy, Competence, Relatedness, Motivation, Trans-contextual model of motivation, Theory of planned behavior

Background

Physical activity (PA) is beneficial for both physical and mental health for people of all age groups. The benefits of PA for adolescents range from better cardiometabolic health to reduced anxiety and better academic performance [1–3]. The psychological benefits of PA are crucial, particularly given the frequency of mental health disorders among adolescents [4]. On the other hand, insufficient PA has detrimental health effects in the long run, as inactivity in childhood may lead to developing various non-communicable diseases in adulthood [5, 6]. Based on the above, World Health Organization (WHO) recommends that children and adolescents achieve an average of 60 min of moderate-to-vigorous PA per day, accumulated over the course of a week [7]. However, 81% of adolescents around the world are physically inactive [8]. Another problem in addition to the insufficient PA, is the fact that PA levels tend to decline with age [9], with sedentary time increasing at the expense of PA [10]. PA trajectories into adulthood are heterogeneous, with most adolescents belonging to the low PA level group, and are influenced by various factors, including psychological and social [11, 12]. As PA patterns tend to carry forward into adulthood [13], it is becoming increasingly important to find effective ways to encourage PA in adolescents.

One of the most used theoretical frameworks to understand motivational processes in the PA context is self-determination theory [14]. This theory differentiates various forms of motivation along a continuum from extrinsic to intrinsic, highlighting the degree to which motivation is autonomous [14]. One of the main premises of self-determination theory states that in order to develop more autonomous forms of motivation towards an activity, a person's three basic psychological needs for autonomy, competence, and relatedness within this activity must be fulfilled. Firstly, the need for autonomy means that a person wants to feel in control of his/her life. Secondly, the need for competence indicates a person's desire to be presented with optimal challenges and experience success. Thirdly, the need for relatedness refers to one's desire to feel a meaningful connection with others. To experience optimal wellbeing, a person's social environment, including interaction with parents, teachers, peers etc., should be supportive of these innate psychological needs [15, 16]. So to encourage PA in children and adolescents, interventions to support their basic psychological needs in the PA context could be used. For example, Teixeira and colleagues [17] identified and classified 21 relevant motivation and behavior change techniques that are used to support basic psychological needs in self-determination theory informed health interventions. It has been demonstrated that interventions in the health domain using self-determination theory as a theoretical framework have been effective in positively changing health behavior [18].

As mentioned above, the social environment must support the fulfillment of basic psychological needs. Hence, parents, physical education (PE) teachers and peers are important social agents when it comes to adolescents' leisure-time PA behavior. A supportive influence from these social agents is demonstrated to be positively associated with adolescents' leisure-time PA intention [19].

Both teachers and parents use a mixture of different teaching and motivational styles daily, not being entirely need-supportive nor need-thwarting [20, 21]. It is possible to cluster teachers and parents into profiles by the degrees of need-supportive and need-thwarting behaviors they use, and it has been shown that when children perceive their teachers and parents as more autonomy- or generally need-supportive, it results in the most adaptive outcomes both in academic and athletic domains [20, 21]. When considering specifically PA, need satisfaction in PE classes is positively correlated with the amount of leisure-time PA the students are getting, so it is important to find ways to support their basic psychological needs to avoid decline in PA levels [22].

PE classes are an excellent setting to carry out PA interventions as in class it is possible to reach virtually all children. Numerous interventions have been successfully conducted in the school context guiding PE teachers to adopt need-supportive teaching strategies [23]. Such interventions promote autonomous motivation towards PA in the school context, but also towards leisure-time PA. This transfer of motivation from one context to another is explained in the trans-contextual model of motivation [24]. The trans-contextual model is a multi-theory approach that combines the tenets and hypotheses of self-determination theory, the theory of planned behavior and the hierarchical model of intrinsic and extrinsic motivation [25]. Research applying the trans-contextual model has demonstrated that children and adolescents who experience more autonomy support in PE classes are more likely to be active in their leisure-time, as a result of higher autonomous motivation, social cognition beliefs and intention towards PA [26]. The trans-contextual model has also been extended to include autonomy support from additional social agents (i.e., peers and parents) and cover basic psychological needs [27].

The interventions including parents in the home setting are not as numerous compared to the school context. However, parents have a crucial role in promoting the activity levels of children in all settings [28]. Understandably, interventions aimed at increasing young children's (0–5 years) PA levels have shown to be most effective when parents are the targets of the intervention and a childcare center is involved [6]. Nevertheless, ongoing parental support for PA is still important in adolescence [29], with parental influence actually being more relevant than PE teachers' influence [30]. As an example of a school- and home-based health intervention, Robbins and colleagues [31] recruited student-parent pairs into their study aimed at improving adolescents' PA levels and eating habits. The parents had a dedicated Facebook group to assist them in supporting children with exercising and healthy eating. The students of parents assigned to the intervention group had higher autonomous motivation towards PA and self-efficacy for healthy eating post-intervention. Parents participating in post-intervention focus groups revealed that they benefited from the information, strategies, and the possibility of exchanging experiences with other parents [31]. While parents admit they have a crucial role in shaping their children's health habits, they often feel they do not have the necessary knowledge and skills to do so [32].

Digital technology can be successfully integrated into behavioral interventions, making them more personalized, self-paced, and scalable [33]. Interventions delivered in an entirely web-based format have demonstrated to be effective in changing adolescents' PA related outcomes [34–36]. For example, a web-based need-supportive intervention program for parents led to adolescents' lower perceptions of autonomy frustration and introjected motivation and higher perceptions of intrinsic motivation in the leisure-time PA context [34]. Another example from school context is a web-based autonomy-supportive intervention program for PE teachers that resulted in students' higher perceptions of PE teacher autonomy-supportive behavior and students' need satisfaction in school context [35, 36]. However, while there are several interventions that have targeted PE teachers or parents separately, there is limited evidence on the combined effect of web-based interventions involving both parents and teachers on adolescents' motivation and engagement in leisure-time PA.

The present study

We have developed two entirely web-based intervention programs, for PE teachers and parents to teach them need-supportive behaviors and hence promote adolescents' motivation towards, and effort to engage in leisure-time PA. The study programs consisted of short video lectures about need-supportive techniques the parents and PE teachers can use when interacting with children. The programs are described in more detail in the methods section.

The aim of the study was to assess the effectiveness of each developed web-based need-supportive intervention individually, as well as their combined effect, on changes in adolescents' PA related outcomes. We hypothesized that both PE teacher and parent need-supportive interventions are predictors of change in study variables. Specifically, we expected that the interventions would affect changes in perceived need-support from PE teachers and parents, autonomous and controlled motivation in PE and in leisure time, attitude, subjective norms, perceived behavioral control, intention, and effort towards leisure-time PA. The hypothetical path model is presented in Fig. 1.

Methods

Experimental design

We used a cluster-randomized controlled design with four study groups. Randomization was conducted at the school level, with schools serving as clusters. A computer-generated randomization sequence was used to assign schools to one of the four study groups. Stratification was applied to ensure balance across geographic location. The four study groups were: (1) PE teacher training group; (2) parent training group; (3) combined PE teacher and parent training group; (4) control group. Respective to their assigned group, PE teachers and parents either participated in a 4-week web-based need-supportive training program or continued teaching and

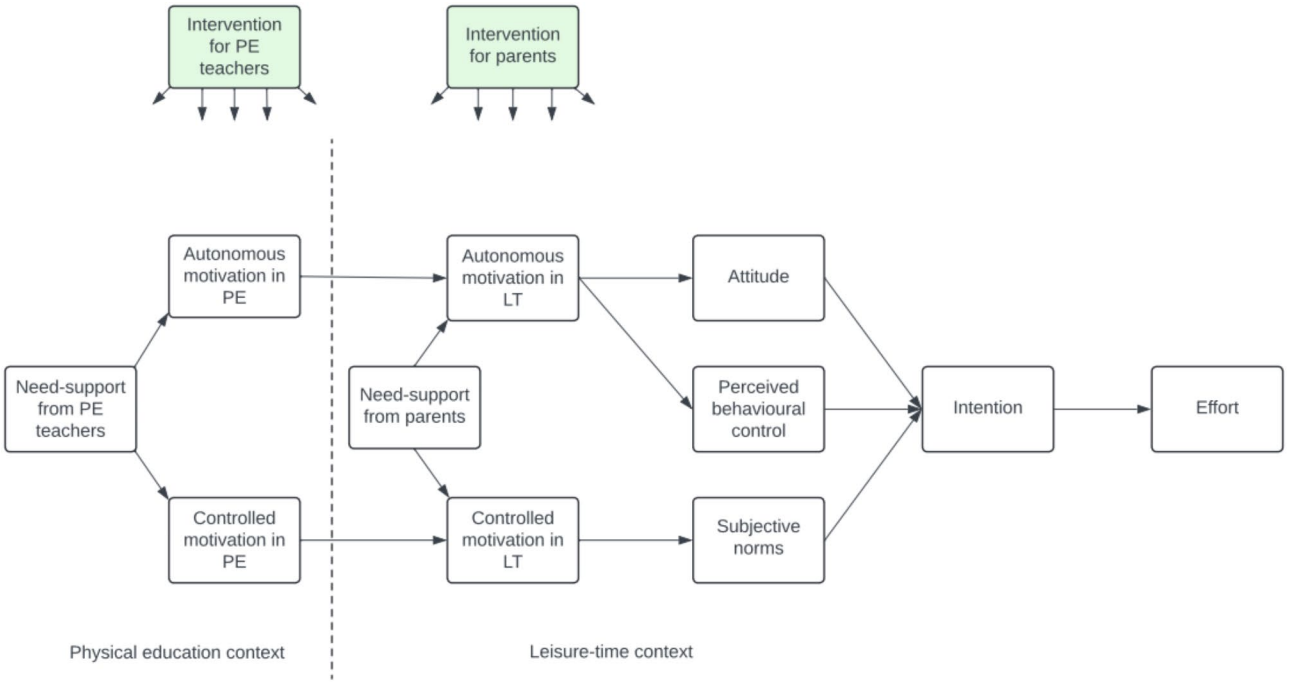

Fig. 1 The hypothetical path model. For clarity, the intervention effects are depicted by a few short arrows, but we expected both interventions to affect each variable in the model. PE = physical education; LT = leisure-time

parenting as usual. Students were not informed of their allocation.

Measurements were collected in four timepoints (baseline, post-intervention, 1-month follow-up, 6-month follow-up) via electronic questionnaires. PE teachers and parents who were not in experimental groups received the training after the 6-month follow-up data collection occasion.

Participants

Eligible participants were Grade 6–7 students with no restrictions on their participation in PE classes, their parents, and their PE teachers. Invitation letters to participate in the study were sent to randomly selected schools from all counties of Estonia. After confirmation from the school, electronic invitation letters to students and parents were sent via eKool or Stuudium, web-based school management platforms in Estonia that connect students, teachers, and parents. These platforms enable management of learning materials, grades, and communication between members. Information about the study and consent forms were also distributed via social media, adding participants to control and parents training alone groups. Students and parents who were willing to participate, filled in an electronic consent form, and the resulting pairs were added to the participants' list. Subsequent questionnaires were also distributed electronically, using e-mail addresses provided in consent forms. The intervention was carried out in the 2023/24 school year.

To determine the necessary sample size for testing the study hypotheses, a power analysis was performed using A-priori Sample Size Calculator for Structural Equation Models [37]. The analysis indicated that a minimum of 90 participants is required to achieve 80% power for detecting medium effects at a significance level of $\alpha = 0.05$. We recruited a total sample size of 115 child (55 boys, 60 girls) and parent (5 male, 110 female) pairs to participate in the study. The ages of children ranged from 11 to 15 years (M_{age} = 12.47, $SD = 0.68$) and the ages of parents ranged from 30 to 57 years (M_{age} = 42.45, $SD = 5.95$). Participant flow through the study is depicted in Fig. 2.

As shown in Fig. 2, the completion rate for students across the study was 62.6%, with 72 out of the 115 students completing the study through all data collection occasions. The completion rate reported reflects linked data for student-parent pairs. While parents demonstrated a higher completion rate filling the questionnaires, the overall completion rate was limited by the students' responses, as their participation was lower in comparison.

Ethical considerations

The study was carried out in accordance with the Declaration of Helsinki and approved by the Research Ethics Committee of the University of Tartu. The CONSORT guidelines were used for reporting the results of the study [38].

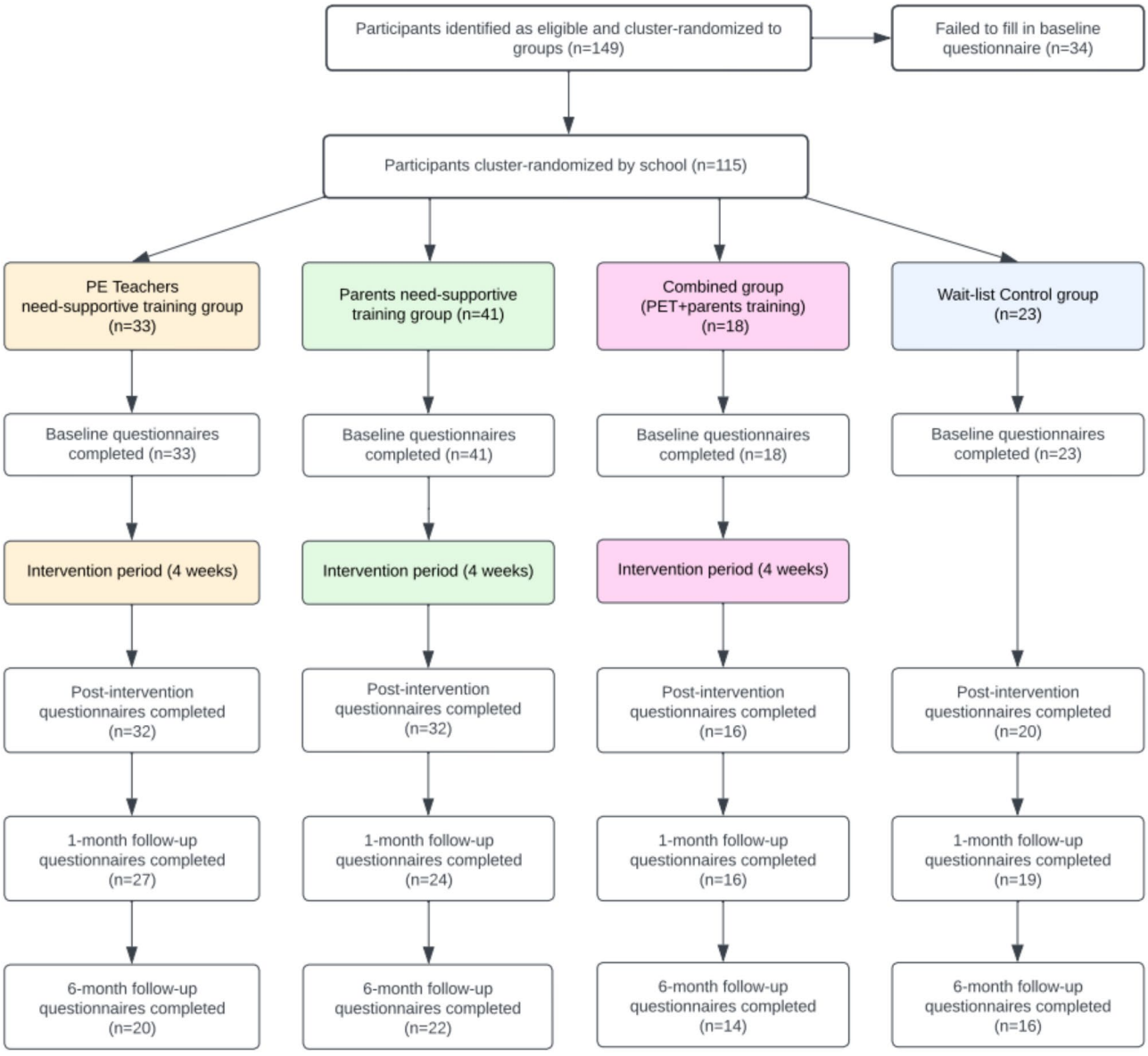

Fig. 2 Participant flow chart and overall study design

Informed consent forms for children and parents were distributed electronically, with the possibility of contacting the researchers when questions arose. The informed consent forms included information about the study aim, procedures, duration, potential benefits, and risks. It was emphasized that their anonymity would be guaranteed, and that participation is voluntary, so they can withdraw from the study without negative consequences. To match participants' responses from different data collection occasions, we asked for the three first letters of the child's name, child's birthday's first number (e.g., if birthday is on 30.07.2010, write 30), three first letters of the mother's name and initials of the PE teacher. Students and parents were matched at a group level for analysis purposes. However, we did not specifically analyze the impact of individual parent participation on student outcomes due to ethical considerations and the need to maintain anonymity. The study did not harm the participants neither mentally nor physically, and invasive research methods were not used.

Web-based need-supportive intervention programs

The web-based intervention programs aimed to teach PE teachers and parents need-supportive motivational techniques to foster children's intrinsic motivation for leisure-time PA. The parental intervention implemented in this study is similar to the approach previously used in the study by Meerits et al. [34], while the teacher-focused intervention was piloted in the study by Paap et al. [39]. Separate context-modified Moodle sites were created

for PE teachers and parents, with a similar structure and access provided during the 4-week training. Invitation links to join the course were sent to PE teachers and parents who were assigned to corresponding study groups.

The programs began by introducing the aims and procedures of the respective courses. Next, self-determination theory was presented, especially the role of basic psychological needs for autonomy, competence, and relatedness in developing autonomous forms of motivation. The main educational content of the programs was based on the motivational and behavior change techniques described by Teixeira and colleagues [17]. These techniques are organized by the three basic psychological needs, with 7 practices available for satisfying each need. Strategies like offering meaningful choices (autonomy support), offering constructive and clear feedback (competence support), and using empathetic listening (relatedness support) are covered in the techniques [17]. We adapted the general practices to either school PE lesson or parent-child interaction and leisure-time PA context.

The need-supportive intervention programs consisted of short educational videos (up to 5 min long) and were self-paced. PE teachers and parents were asked to watch 5–6 videos per week, but they could decide when to do it. The educational materials from previous weeks were also accessible until the end of the program. Each video introduced a specific behavioral technique to support one of the basic psychological needs. The videos started with explaining the targeted basic psychological need of this technique. Next, the technique itself and the expected benefits of its application were introduced, and finally a sample video clip was presented of the application of this technique in interaction with children by either PE teachers or parents. A more detailed description of the educational videos can be found in the supplementary file.

After watching each week's educational videos, parents and PE teachers were asked to complete a short multiple-choice quiz designed to provide feedback on their understanding of the techniques introduced. Each quiz included one question per technique to ensure participants grasped the underlying logic. Additionally, an open forum was made available on Moodle, where participants were encouraged to reflect on their experiences applying the techniques in real interactions with children. To facilitate engagement, a new discussion thread was initiated each week, prompting participants to share their reflections and challenges in implementing the techniques. Overview of these educational activities in Moodle suggested that PE teachers and parents were engaged in the program. The weekly tests were completed by 83% of PE teachers and 42% of parents, participation in forum discussions was 63% and 14%, respectively.

Outcome measures

The participating students completed electronic questionnaires on four measuring occasions (i.e., baseline, post-intervention, 1-month and 6-month follow-ups). All measures were self-reported. Responses were collected on 7-point Likert scales with endpoints meaning *strongly disagree* [1] and *strongly agree* [7], unless stated otherwise.

Perceived need support

Students' perceptions of their parents' and their PE teachers' need-supportive behaviors regarding PA were measured by the perceived autonomy support scale [40] and the need support scale [41]. In the case of parents, the scales were modified to the home setting. The final scale to measure perceived need support from parents consisted of 13 items, four items to measure autonomy support and competence support, five items to measure relatedness support. Perceived need-support from PE teachers was measured by 16 items, seven for autonomy support, 4 for competence support and 5 for relatedness support. Example items from the scales are: "I feel that my PE teacher/parent provides me with choices and opportunities about whether to do active sports and/or vigorous exercise (in my free time)" (perceived autonomy support); "I feel that my PE teacher/parent helps me to improve (in leisure-time PA)" (perceived competence support); "I feel that my PE teacher/parent is interested in my experiences" (perceived relatedness support). Previous research has proven the perceived autonomy support scale to be a reliable and valid measure to assess perceived autonomy support from PE teachers and parents [42], and it has been used with Estonian students in a similar age group [42, 43]. The need support scale has been demonstrated to be a reliable and valid measure evaluate perceived competence and relatedness support from PE teachers and parents, and it has been used in Estonia [34, 44].

Motivation towards PA

Students' autonomous and controlled forms of motivation towards PE and in leisure-time were evaluated using the adapted version of the perceived locus of causality questionnaire [45] referring to either school or out-of-school contexts. All items have a common stem "I participate in physical education class /I am physically active in my free time…" and are followed by statements assessing intrinsic motivation ("…because I enjoy it"), identified regulation ("…because it is important to me"), introjected regulation ("…I will feel bad about myself if I don't"), and external regulation ("…I feel pressure to do it"). Previous studies have shown this instrument to be reliable and valid [43, 46, 47], and it has been used in Estonia [43, 47].

Theory of planned behavior constructs

Attitude, subjective norms, perceived behavioral control, and intention towards leisure-time PA were measured using scales developed according to the recommended guidelines [48]. Attitude was measured by three items following a common stem "For me, participating in active sports and/or vigorous physical activities during my free time in the next 5 weeks…". These three items were reported using 7-point scales with bipolar adjectives on each end (unenjoyable/enjoyable, bad/good, useless/useful). Subjective norms were measured by two items ("Most people close to me expect me to do active sports and/or vigorous physical activities during my free time in the next 5 weeks"). Perceived behavioral control was evaluated by two items (e.g., "How much control do you have over doing active sports and/or vigorous physical activities during your free time in the next 5 weeks?") and the responses were collected on 7-point scales with endpoints meaning *very little control* [1] and *full control* [7]. Intention was assessed by two items (e.g., "I intend to do active sports and/or vigorous physical activities during my free time in the next 5 weeks"). The described measures have been demonstrated to be reliable and valid [25, 42] and have been used in Estonia [43].

Perceived effort

Students self-reported their effort towards leisure-time PA using the scale developed by Hagger and Hamilton [49]. Effort was assessed by two items (e.g., "During the last 5 weeks, how hard did you try to be physically active in your free time?"). Responses were collected using 7-point Likert scales with endpoints meaning *did not try at all* [1] and *tried extremely hard* [7]. This measure has been demonstrated to be reliable and valid [49, 50], and has been used in Estonia [50].

Data management and analysis

Study data were collected and managed using REDCap (Research Electronic Data Capture) electronic data capture tools [51, 52] hosted at the local university. REDCap is a secure, web-based software platform designed to support data capture for research studies, providing (1) an intuitive interface for validated data capture; (2) audit trails for tracking data manipulation and export procedures; (3) automated export procedures for seamless data downloads to common statistical packages; and (4) procedures for data integration and interoperability with external sources.

Data analysis was carried out using SPSS Version 29 (IBM Corp., Armonk, NY, USA) and SPSS AMOS Version 29 (IBM Corp., Armonk, NY, USA). The web-based questionnaire did not permit students to leave questions unanswered, so there were no missing values. The reliability of the scales in the questionnaire was assessed by Cronbach's alpha coefficient [53]. Composite scores were computed for perceived need support from PE teachers and from parents (average of the items in autonomy, competence and relatedness support scales in both contexts), autonomous motivation in PE and towards leisure-time PA (average of the items in intrinsic motivation and identified regulation scales in both contexts), controlled motivation in PE and towards leisure-time PA (average of the items in introjected and external regulation scales in both contexts). Normal distribution of the data was assessed by asymmetry and kurtosis values (from −2 to +2 and from −7 to +7, respectively) [54].

A series of analysis of variance (ANOVA) tests were used to conduct the randomization check to examine baseline differences between study groups. Independent samples *t*-tests were used to conduct the attrition test to identify any significant differences between participants who remained in the study and those who dropped out. Chi-square tests were used to examine any possible differences in gender comparing study groups and attrition status.

In the main analysis, the effects of the interventions on study variables were tested by using path analysis. For the path analysis, residual change scores for each of the variables were calculated by regressing the scores for the variables measured at follow-ups on their baseline scores. The effects of both interventions were examined by predicting changes in the study variables using dichotomous intervention variables, coded as 1 = no intervention and 2 = intervention. The path analysis was carried out using a maximum likelihood method with 5000 bootstrap resamples [54]. Four different path models were tested (combined intervention, teacher intervention alone, parental intervention alone, no intervention). The model fit was evaluated by using the following goodness-of-fit indices: comparative fit index (CFI), standardized root mean square residual (SRMR), and the root mean square error of approximation (RMSEA) [55]. Values above 0.90 for CFI and below 0.08 for SRMR and RMSEA were considered indicative of good model fit.

Results

Preliminary analysis

Cronbach's alpha values exceeded the acceptable level of 0.7 [53], except controlled motivation in PE and subjective norms (Table 1). The skewness (-1.94 to 0.57) and kurtosis values (-0.81 to 4.13) in the study were within the acceptable range [54].

The results of the series of ANOVA tests demonstrated that there were no significant differences in any of the study variables between the study groups at baseline ($F = 0.18–1.60$, $p > 0.15$). There were also no significant differences between the study groups in the proportion

Table 1 Intercorrelations of study variables

Variable	1	2	3	4	5	6	7	8	9	10	11
1. Need support (PET)	(0.92)										
2. Aut.mot (PE)	0.61**	(0.90)									
3. Contr.mot (PE)	0.05	0.12	(0.64)								
4. Need support (parent)	0.57**	0.34**	0.002	(0.91)							
5. Aut.mot (LT)	0.24	0.24	0.19	0.28*	(0.87)						
6. Contr.mot (LT)	0.23	0.03	0.34**	0.13	0.38**	(0.73)					
7. Attitude	0.25	0.12	-0.03	0.37**	0.52**	0.03	(0.92)				
8. PBC	0.26*	0.15	-0.01	0.36**	0.49**	0.22	0.65**	(0.78)			
9. Subjective norms	0.24	-0.11	0.21	0.27*	0.09	0.48**	0.07	0.14	(0.55)		
10. Intention	0.22	0.07	-0.14	0.34*	0.38**	0.02	0.60**	0.55**	0.16	(0.95)	
11. Effort	0.01	0.04	-0.06	0.17	0.50**	0.14	0.44**	0.52**	0.09	0.54**	(0.84)

Note. All study variables were residual change scores. Cronbach alpha values for the scales used in the questionnaire are presented in parentheses for each variable. PE = physical education; PET = PE teacher; LT = leisure-time context; Aut.mot. = autonomous motivation; Contr.mot. = controlled motivation; PBC = perceived behavioural control. *$p < 0.05$, **$p < 0.01$

of boys and girls ($\chi^2 = 2.65$, $p = 0.50$) and in the age of the participating students ($F = 0.78$, $p = 0.57$).

Attrition across four data collection occasions resulted in the final sample size of 72 students (32 boys, 40 girls; M_{age} = 12.43, $SD = 0.58$; attrition rate 37.4%). The results of the *t*-tests demonstrated that there were no significant differences in any of the study variables at baseline between the students who completed the study with all data collection occasions and who dropped out (t = -1.81–0.47, $p > 0.05$), except perceived behavioral control regarding leisure-time PA. In the latter variable, students who dropped out demonstrated significantly higher scores at baseline compared to the students who remained in the study (t = -2.38, $p = 0.02$). There were no significant differences between the students who remained in the study and who were lost in follow-ups in the proportion of boys and girls ($\chi^2 = 1.29$, $p = 0.26$) and in the age of the participating students (t = -0.87, $p = 0.39$) at baseline.

The intercorrelations of residual change scores are presented in Table 1.

Main analysis

The results of the path analysis using standardized parameter estimates are presented in Fig. 3. The tested path models demonstrated good fit with the data (combined intervention: $\chi^2 = 37.03$, df = 35, $p = 0.376$, CFI = 0.99, SRMR = 0.062, RMSEA = 0.032; teacher intervention alone: $\chi^2 = 36.38$, df = 35, $p = 0.404$, CFI = 0.99, SRMR = 0.068, RMSEA = 0.026; parental intervention alone: $\chi^2 = 42.09$, df = 35, $p = 0.191$, CFI = 0.96, SRMR = 0.080, RMSEA = 0.060; no intervention: $\chi^2 = 40.88$, df = 35, $p = 0.228$, CFI = 0.97, SRMR = 0.087, RMSEA = 0.054).

Direct effects

Parameter estimates and bias-corrected bootstrapped 95% confidence intervals for the direct effects from all four tested path models are presented in Table 2.

The need-supportive intervention for PE teachers had a statistically significant direct effect on changes in perceived need-support from parents ($\beta = 0.28$, $p = 0.027$, 95% CI [0.03, 0.48]), controlled motivation in PE (β = -0.25, $p = 0.042$, 95% CI [-0.48, -0.01]), attitude towards leisure-time PA ($\beta = 0.24$, $p = 0.016$, 95% CI [0.05, 0.46]), and perceived behavioral control regarding leisure-time PA ($\beta = 0.30$, $p = 0.006$, 95% CI [0.10, 0.48]).

Change in perceived need-support from PE teachers had a statistically significant direct effect on change in autonomous motivation in PE ($\beta = 0.61$, $p = 0.001$, 95% CI [0.43, 0.80]). Change in perceived need-support from parents had a statistically significant direct effect on change in autonomous motivation towards leisure-time PA ($\beta = 0.29$, $p = 0.041$, 95% CI [0.01, 0.60]).

Change in controlled motivation in PE had a statistically significant direct effect on change in controlled motivation towards leisure-time PA ($\beta = 0.32$, $p = 0.031$, 95% CI [0.03, 0.59]). Change in autonomous motivation towards leisure-time PA had a statistically significant direct effect on changes in attitude towards leisure-time PA ($\beta = 0.58$, $p = 0.001$, 95% CI [0.36, 0.74]) and perceived behavioral control regarding leisure-time PA ($\beta = 0.55$, $p < 0.001$, 95% CI [0.28, 0.74]). Change in controlled motivation towards leisure-time PA had a statistically significant direct effect on change in subjective norm ($\beta = 0.50$, $p = 0.002$, 95% CI [0.23, 0.70]).

Change in attitude towards leisure-time PA had a statistically significant direct effect on change in intention to engage in leisure-time PA ($\beta = 0.45$, $p = 0.005$, 95% CI [0.17, 0.68]). Change in intention to engage in leisure-time PA had a statistically significant direct effect on change in effort to engage in leisure-time PA ($\beta = 0.38$, $p = 0.002$, 95% CI [0.15, 0.58]).

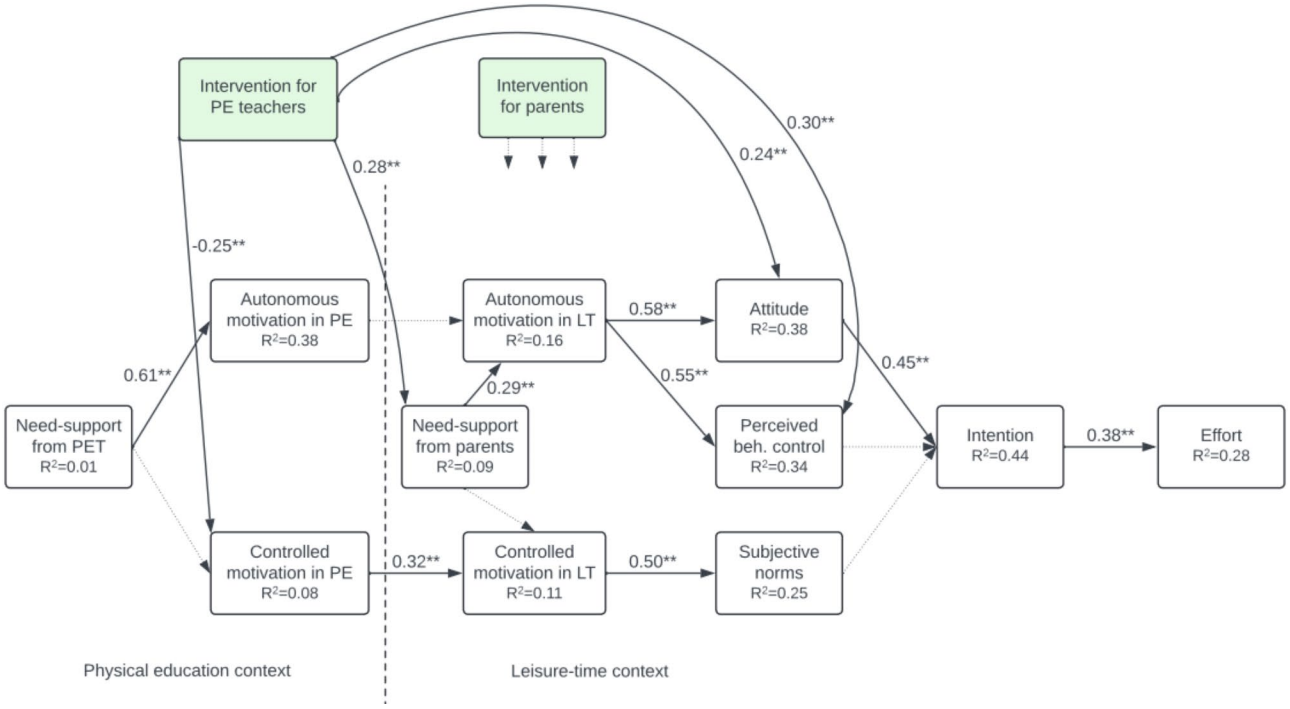

Fig. 3 Results of the path analysis testing the effects of combined need-supportive intervention programs for PE teachers and parents. *Note*. All psychometric variables were residual change scores. The following covariances were added: need-support from PE teachers and need-support from parents; autonomous and controlled motivation in PE; autonomous and controlled motivation towards leisure-time PA; attitude and perceived behavioral control; attitude and subjective norms; perceived behavioral control and subjective norms; autonomous motivation towards leisure-time PA and effort towards leisure-time PA. For clarity, the non-significant paths are presented in gray. PE = physical education; PET = physical education teacher; LT = leisure-time; Perceived beh. control = perceived behavioral control. *$p < 0.05$, **$p < 0.01$

Indirect effects

Parameter estimates and bias-corrected bootstrapped 95% confidence intervals from the path analysis model of the combined intervention for both PE teachers and parents for indirect effects are presented in Table 3.

Significant indirect effects were observed for changes in perceived need-support from parents on changes in perceived behavioral control ($\beta = 0.16$, $p = 0.039$, 95% CI [0.01, 0.40]) and attitude ($\beta = 0.17$, $p = 0.035$, 95% CI [0.11, 0.39]). Additionally, a significant indirect effect was found for changes in perceived need-support from parents on intention to engage in leisure-time PA ($\beta = 0.12$, $p = 0.032$, 95% CI [0.01, 0.29]), as well as on effort to engage in leisure-time PA ($\beta = 0.05$, $p = 0.023$, 95% CI [0.01, 0.15]). Furthermore, a significant indirect effect of changes in controlled motivation in PE on changes in subjective norm was found ($\beta = 0.16$, $p = 0.017$, 95% CI [0.03, 0.34]). For autonomous motivation towards leisure-time PA, significant indirect effects were identified for changes in both intention to engage in leisure-time PA ($\beta = 0.39$, $p < 0.001$, 95% CI [0.21, 0.55]) and effort to engage in leisure-time PA ($\beta = 0.15$, $p = 0.001$, 95% CI [0.05, 0.28]). Finally, a significant indirect effect of changes in attitude towards leisure-time PA on changes in effort to engage in leisure-time PA was also found ($\beta = 0.17$, $p = 0.006$, 95% CI [0.04, 0.33]).

Specific indirect effects

Based on our hypothetical path model, the effect of changes in perceived need-support from parents can guide changes in intention and effort towards leisure-time PA either via attitude or via perceived behavioral control. Thus, we estimated the significance of (1) two specific indirect effects from perceived need-support from parents to intention, and (2) two specific indirect effects from perceived need-support from parents to effort.

Our results demonstrate that regarding changes in intention, the sequence perceived need-support from parents, autonomous motivation towards leisure-time PA, attitude, and intention was stronger ($B = 0.06$, $p = 0.025$, 95% CI [0.01, 0.20]). The sequence mediated by perceived behavioral control instead of attitude was non-significant.

Regarding changes in effort, the sequences perceived need-support from parents, autonomous motivation towards leisure-time PA, attitude, intention, effort ($B = 0.04$, $p = 0.024$, 95% CI [0.00, 0.16]), and perceived need-support from parents, autonomous motivation

Table 2 Direct effects from path analysis models using residual change scores

Independent variable	Dependent variable	Path model with combined intervention			Path model with PE teacher intervention alone			Path model with parental intervention alone			Path model with no intervention		
		β	CI_{95} LL	CI_{95} UL	β	CI_{95} LL	CI_{95} UL	β	CI_{95} LL	CI_{95} UL	β	CI_{95} LL	CI_{95} UL
Teacher training	PNS (PET)	0.02	-0.25	0.27	0.02	-0.24	0.27						
Teacher training	PNS (par)	0.28*	0.03	0.48	0.28*	0.04	0.46						
Teacher training	Aut.mot. (PE)	-0.06	-0.27	0.14	-0.06	-0.27	0.14						
Teacher training	Contr.mot. (PE)	-0.25*	-0.48	-0.01	-0.26*	-0.48	-0.01						
Teacher training	Aut.mot. (LT)	-0.23	-0.46	0.03	-0.23	-0.45	0.01						
Teacher training	Contr.mot. (LT)	0.02	-0.30	0.32	0.02	-0.29	0.31						
Teacher training	Attitude	0.24*	0.05	0.46	0.25*	0.05	0.44						
Teacher training	PBC	0.30**	0.10	0.48	0.30**	0.10	0.48						
Teacher training	Subjective norm	-0.02	-0.26	0.21	-0.03	-0.25	0.21						
Teacher training	Intention	0.08	-0.16	0.31	0.08	-0.16	0.31						
Teacher training	Effort	0.12	-0.10	0.34	0.12	-0.11	0.33						
Parent training	PNS (PET)	-0.09	-0.36	0.18				-0.09	-0.36	0.17			
Parent training	PNS (par)	0.11	-0.15	0.34				0.10	-0.16	0.33			
Parent training	Aut. mot. (PE)	-0.05	-0.27	0.17				-0.04	-0.27	0.16			
Parent training	Contr. mot. (PE)	0.11	-0.17	0.35				0.12	-0.16	0.36			
Parent training	Aut.mot. (LT)	0.08	-0.19	0.32				0.10	-0.18	0.33			
Parent training	Contr.mot. (LT)	-0.04	-0.29	0.23				-0.04	-0.29	0.22			
Parent training	Attitude	-0.21	-0.39	0.01				-0.21	-0.41	0.01			
Parent training	PBC	-0.07	-0.29	0.15				-0.08	-0.31	0.14			
Parent training	Subjective norm	0.05	-0.19	0.29				0.05	-0.19	0.28			
Parent training	Intention	0.12	-0.09	0.32				0.12	-0.09	0.32			
Parent training	Effort	0.10	-0.13	0.32				0.09	-0.14	0.32			
PNS (PET)	Aut.mot. (PE)	0.61**	0.43	0.80	0.61**	0.43	0.78	0.61**	0.42	0.79	0.61**	0.42	0.77
PNS (PET)	Contr.mot. (PE)	0.07	-0.16	0.29	0.06	-0.17	0.27	0.06	-0.17	0.31	0.05	-0.18	0.28
PNS (par)	Aut.mot. (LT)	0.29*	0.01	0.60	0.30*	0.03	0.61	0.20	-0.07	0.52	0.21	-0.05	0.53
PNS (par)	Contr.mot. (LT)	0.13	-0.21	0.48	0.13	-0.21	0.45	0.14	-0.21	0.44	0.14	-0.20	0.41
Aut.mot. (PE)	Aut.mot. (LT)	0.15	-0.10	0.47	0.14	-0.10	0.45	0.19	-0.08	0.50	0.18	-0.09	0.48
Contr.mot. (PE)	Contr.mot. (LT)	0.32*	0.03	0.59	0.31*	0.03	0.59	0.29*	0.04	0.53	0.29*	0.03	0.53
Aut.mot. (LT)	Attitude	0.58**	0.36	0.74	0.56**	0.35	0.72	0.55**	0.29	0.72	0.52**	0.29	0.69
Aut.mot. (LT)	PBC	0.55***	0.28	0.74	0.54***	0.28	0.73	0.50**	0.21	0.71	0.49**	0.20	0.71
Contr.mot. (LT)	Subjective norm	0.50**	0.23	0.70	0.49**	0.22	0.69	0.50**	0.23	0.69	0.49**	0.22	0.69
Attitude	Intention	0.45**	0.17	0.68	0.42**	0.13	0.64	0.45**	0.15	0.67	0.42*	0.12	0.64
PBC	Intention	0.23	-0.05	0.48	0.25	-0.02	0.49	0.25	-0.03	0.52	0.26	-0.02	0.53
Subjective norm	Intention	0.09	-0.13	0.32	0.10	-0.11	0.32	0.08	-0.13	0.32	0.09	-0.12	0.31
Intention	Effort	0.38**	0.15	0.58	0.38**	0.16	0.58	0.43**	0.18	0.62	0.43**	0.19	0.63

Notes.β = Standardized parameter estimate; Teacher training = Need-supportive intervention program for physical education teachers; Parent training = Need-supportive intervention program for parents; PE = physical education; PET = PE teacher; par = parent; PNS = perceived need-support; LT = leisure-time; Aut.mot. = autonomous motivation; Contr.mot. = controlled motivation; PBC = perceived behavioural control. LL = lower limit of 95% CI; UL = upper limit of 95% CI. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Table 3 Indirect effects from path analysis models of the combined intervention using residual change scores

Independent variable	Dependent variable	β	CI_{95} LL	CI_{95} UL	Independent variable	Dependent variable	β	CI_{95} LL	CI_{95} UL
Teacher training	Aut. mot. (PE)	0.01	-0.18	0.15	Need-support (PET)	SN	-0.01	-0.02	0.06
Teacher training	Contr. mot. (PE)	0.00	-0.03	0.05	Need-support (PET)	Intention	0.04	-0.02	0.12
Teacher training	Aut.mot. (LT)	0.08	-0.05	0.25	Need-support (PET)	Effort	0.01	-0.01	0.05
Teacher training	Contr.mot. (LT)	-0.04	-0.21	0.13	Need-support (par)	Attitude	0.17*	0.11	0.39
Teacher training	Attitude	-0.09	-0.25	0.06	Need-support (par)	PBC	0.16*	0.01	0.40
Teacher training	PBC	-0.08	-0.23	0.05	Need-support (par)	SN	0.07	-0.09	0.28
Teacher training	SN	-0.01	-0.16	0.12	Need-support (par)	Intention	0.12*	0.01	0.29
Teacher training	Intention	0.12	-0.05	0.30	Need-support (par)	Effort	0.05*	0.01	0.15
Teacher training	Effort	0.07	-0.02	0.20	Aut. mot. (PE)	Attitude	0.08	-0.06	0.26
Parent training	Aut. mot. (PE)	-0.06	-0.27	0.09	Aut. mot. (PE)	PBC	0.08	-0.05	0.25
Parent training	Contr. mot. (PE)	-0.01	-0.10	0.02	Aut. mot. (PE)	Intention	0.06	-0.03	0.18
Parent training	Aut.mot. (LT)	0.02	-0.10	0.15	Aut. mot. (PE)	Effort	0.02	-0.01	0.08
Parent training	Contr.mot. (LT)	0.05	-0.06	0.17	Contr. mot. (PE)	SN	0.16*	0.03	0.34
Parent training	Attitude	0.05	-0.11	0.22	Contr. mot. (PE)	Intention	-0.01	-0.01	0.07
Parent training	PBC	0.05	-0.10	0.20	Contr. mot. (PE)	Effort	-0.01	0.00	0.03
Parent training	SN	0.00	-0.13	0.15	Aut.mot. (LT)	Intention	0.39***	0.21	0.55
Parent training	Intention	-0.07	-0.25	0.10	Aut.mot. (LT)	Effort	0.15**	0.05	0.28
Parent training	Effort	0.02	-0.08	0.13	Contr.mot. (LT)	Intention	-0.05	-0.06	0.17
Need-support (PET)	Aut.mot. (LT)	0.09	-0.06	0.31	Contr.mot. (LT)	Effort	-0.02	-0.02	0.08
Need-support (PET)	Contr.mot. (LT)	0.02	-0.05	0.13	Attitude	Effort	0.17**	0.04	0.33
Need-support (PET)	Attitude	0.05	-0.03	0.18	PBC	Effort	0.09	-0.01	0.23
Need-support (PET)	PBC	0.05	-0.03	0.17	Subjective norm	Effort	0.03	-0.05	0.14

*Notes.*β = Standardized parameter estimate; Teacher training = Need-supportive intervention program for physical education teachers; Parent training = Need-supportive intervention program for parents;; PE = physical education; PET = PE teacher; par = parent; LT = leisure-time; Need-support (PET) = perceived need-support from PE teacher; Need-support (par) = perceived need-support from parent; Aut.mot. = autonomous motivation; Contr.mot. = controlled motivation; PBC = perceived behavioural control, SN = subjective norm. LL = lower limit of 95% CI; UL = upper limit of 95% CI. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

towards leisure-time PA, perceived behavioral control, intention, effort ($B = 0.02$, $p = 0.048$, 95% CI [0.00, 0.11]) were both statistically significant, but the sequence mediated by attitude was stronger.

Discussion

The study aimed to investigate the unique and combined effectiveness of web-based need-supportive interventions for PE teachers and parents on changes in adolescents' intention and effort towards leisure-time PA. We expected that both interventions are predictors of change in study variables. Our findings show how perceived need support influences various motivational constructs, consistent with self-determination theory. Our results indicate that when adolescents perceive higher levels of need-support from parents and PE teachers, they exhibit increased autonomous motivation, which subsequently enhances their attitude, intention and effort toward engaging in leisure-time PA. This interplay suggests that fostering need-supportive conditions in both educational and familial contexts is crucial for promoting positive PA behaviors among adolescents.

Previous intervention studies have demonstrated that autonomy-supportive interventions are effective in enhancing students' PA-related outcomes, including perceived PE teacher behavior and intrinsic motivation [35, 56]. Our results revealed that the need-supportive intervention for PE teachers had direct effects on changes in perceived need-support from parents, controlled motivation in PE, attitude towards leisure-time PA and perceived behavioral control regarding leisure-time PA. Changes in parental need-support following PE teacher training can be explained by the teacher-to-parent spillover effect described by Cheon and colleagues [57]. They discovered that students whose PE teachers participated in autonomy-supportive intervention also reported higher perceived autonomy-support from parents, demonstrating that receiving autonomy-support in one relationship likely leads to receiving autonomy-support in a different relationship [57]. This effect underscores the importance of a cohesive approach where both educators and parents work collaboratively to create supportive environments for adolescents. By aligning the strategies used by teachers and parents, we can foster a more holistic support system that encourages adolescents to engage in PA.

In a pilot study of the parental intervention by Meerits and colleagues, decreased controlled motivation towards leisure-time PA was revealed as a result [34]. Robbins and colleagues, in their intervention where parents were involved in improving adolescents' PA levels, demonstrated increased autonomous motivation toward PA as

a result [31]. However, in our study we were not able to demonstrate a significant direct effect of parental need-supportive intervention on study variables. One possible explanation for the limited effects of the parental intervention is the lower engagement levels observed among parents. Unlike PE teachers, whose participation was integrated into their professional roles, parents may have faced competing demands, such as work and household responsibilities, which could have hindered their ability to fully engage with the program content and apply the techniques in practice. The other challenge was the potential selection bias in our participant pool. It is possible that parents who are already more need-supportive and knowledgeable about the benefits of parenting interventions were more likely to participate in the program. This could limit the generalizability of the findings, as the effects of the intervention may not be as noticeable among this group compared to parents with less prior knowledge or motivation. Furthermore, while web-based delivery of parenting interventions has shown significant potential to enhance ongoing engagement compared to face-to-face programs, tailored interventions specifically offer additional opportunities to improve parental involvement. By personalizing content to align with parents' current levels of knowledge, parenting styles, and specific challenges, tailored approaches make programs more relevant, which in turn increases engagement [58]. In our program, we incorporated interactivity through weekly tests and forums for sharing experiences, as well as allowing users to control how and when they engaged with the program. Future programs could enhance engagement by consulting stakeholders during the design process, and integrating features like goal setting, action plans, and adaptive modules that adjust based on initial assessments or ongoing progress [58].

Changes in perceived need-support from PE teachers and parents had significant direct impact on changes in autonomous motivation in PE and LT contexts, respectively. This result is readily explainable by the theoretical framework of the study. According to the self-determination theory, a person's basic psychological needs in an activity have to be satisfied to facilitate the development of autonomous motivation towards this activity [16]. The positive effect of perceived autonomy-support on autonomous motivation towards leisure-time PA has been demonstrated in previous studies [47, 50].

The effect of parental support emerged as a significant predictor of adolescents' autonomous motivation. Autonomy-supportive parenting practices mediate the relationship between parental motivation towards PA and children's participation in PA [59]. Our findings illustrate that perceived need-support from parents not only directly shapes adolescents' autonomous motivation towards leisure-time PA, but also indirectly guides their attitude, perceived behavioral control, intention and effort regarding leisure-time PA. By fostering an environment where children feel supported in their basic psychological needs, parents can significantly enhance their children's motivation to engage in PA.

Changes in perceived need-support from parents also indirectly affect changes in perceived behavioral control, attitude towards leisure-time PA, intention and effort to engage in leisure-time PA. Perceived parental support has been shown to be highly correlated with children's PA levels [60, 61]. Stronger intention towards PA could predict adolescents' future leisure-time PA levels [62].

We found that changes in controlled motivation in PE significantly affect changes in controlled motivation towards leisure-time PA. This relationship follows the sequence described in the trans-contextual model [24], and has also been demonstrated in other studies aimed at increasing the PA levels in adolescents [63].

Our findings indicate that perceived need-support from parents significantly shapes perceived behavioral control, attitude, intention, and effort related to leisure-time PA. This aligns with the findings from Westerskov Dalgas and colleagues [64] which emphasize the importance of autonomy, competence, and relatedness satisfaction across various domains of PA. It has also been demonstrated that specifically competence satisfaction before adolescence predicts higher levels of PA later in adolescence [65]. By enhancing the three basic psychological needs, interventions can foster a stronger motivational foundation for adolescents, leading to sustained engagement in PA.

Practical implications

The findings of this study carry significant implications for the design of future interventions. Training for both teachers and parents in need-supportive strategies is essential to create a cohesive support system for adolescents that fosters healthy behaviors. However, the limited success of the parental intervention, with low engagement rates, underscores the importance of addressing barriers to parental participation. Future programs should consider strategies such as simplifying program delivery, offering tailored programs, incorporating personalized reminders, and providing incentives to encourage engagement.

Specific strategies, such as goal-setting workshops, motivational interviewing techniques, and collaborative planning sessions, can enhance the effectiveness of interventions aimed at increasing PA levels [66]. By equipping both educators and parents with tools to support basic psychological needs, we can foster an environment conducive to promoting healthy behaviors among adolescents.

Strengths, limitations, and future directions

The study has several strengths. Firstly, the study design incorporates support for all three basic psychological needs of autonomy, competence, and relatedness and is based on a specific classification system. Secondly, the study design includes need-support from both PE teachers at school and parents in the home setting, thus covering both contexts expected to affect students' PA related outcomes. However, the study also had some limitations. Firstly, a notable limitation of this study was the low engagement observed among parents participating in the intervention, with only 42% completing the weekly quizzes. This may have affected the overall effectiveness of the parental program and limited its ability to produce significant outcomes. Parents play a crucial role in creating a supportive environment for adolescents' PA by modeling need-supportive behaviors and reinforcing motivational strategies at home. Limited participation in the intervention may have hindered their ability to fully adopt these behaviors, thereby weakening the intended impact on adolescents' motivation and PA levels. This highlights the importance of sustained parental involvement for achieving optimal outcomes and suggests that the results related to parental influence should be interpreted with caution. Secondly, the study faced a relatively high attrition rate (37.4%), which may introduce some bias. While baseline comparisons showed no significant differences between completers and non-completers on most measures, unmeasured differences cannot be entirely ruled out. Future research should replicate these findings in larger samples with lower attrition or assess the impact of missing data through sensitivity analyses. Thirdly, we did not measure students' actual PA levels because using accelerometers was not feasible given our entirely web-based approach. It is recommended that objective measurement via accelerometers is used in future studies to capture actual levels of PA. Fourthly, we did not observe PE teachers and parents' actual interactions with students. While this is feasible to do in the school PE context, observing parents and children in their homes is complicated. In future interventions, it would be recommended that a focus group interview be held with parents to discuss their experiences during the intervention and possibly discover new methods to use for ascertaining the level of compliance with recommended motivational techniques. Fifthly, it is likely that the parents who agreed to take part in the study were already more interested in their children's activity levels and knowledgeable about the importance of sufficient PA. As recruitment is voluntary, a possibility to motivate the less interested parents to participate is to offer them some incentive for participation, e.g., a gift card. Sixthly, the sample size calculation did not explicitly account for the clustered nature of the study design. This omission may have reduced the effective sample size and statistical power, particularly for the parent group, where the low completion rate further amplified this issue. As a result, the robustness of the findings and their generalizability to broader populations may be limited. Seventhly, a limitation of the study is the inability to directly link individual parent participation in the training to their child's outcomes. While students and parents were matched at a group level, ethical considerations and the need to maintain anonymity prevented an analysis of individual-level impacts, which could have provided more precise insights into the role of parental involvement in influencing student outcomes.

While our study provides valuable insights into the effects of the intervention across multiple time points (baseline, post-intervention, and follow-ups), we acknowledge that the use of more advanced analytical approaches, such as cross-lagged panel models, could offer additional insights. However, the feasibility of applying cross-lagged panel models in this study was limited by the reduced sample size at follow-up due to attrition. A smaller sample size at later time points reduces the statistical power and reliability of the estimates, which is a critical consideration for such complex analyses. Future research with greater sample sizes and lower attrition rates could utilize cross-lagged panel models to explore reciprocal relationships between constructs, providing deeper insights into the mechanisms driving changes over time and contributing to the theoretical understanding of intervention effects.

This study utilized self-determination theory and the trans-contextual model of motivation to guide the intervention, emphasizing the role of need-supportive behaviors from parents and PE teachers in fostering adolescents' autonomous motivation and engagement in leisure-time PA. While these frameworks effectively informed the intervention design, the findings highlight the need for improved parental engagement strategies. Future research could integrate the Behaviour Change Wheel [67] to address this gap. This model identifies capability, opportunity, and motivation as key drivers of behavior and offers a systematic approach to identifying and addressing barriers to parental involvement. Elements of the intervention already align with this framework. For example, the use of videos and quizzes directly supports capability by enhancing parents' and PE teachers' psychological capability to provide need-supportive behaviors. Similarly, the inclusion of forum discussions supports opportunity by creating a social environment where parents and teachers can exchange ideas, share experiences, and collaborate on strategies to support adolescents' PA. To further leverage the Behaviour Change Wheel, future interventions could incorporate more tailored resources to strengthen parents' and teachers' capability, develop supportive networks to expand

opportunities, and implement motivational strategies that highlight the benefits of need-supportive behaviors in promoting PA.

Frameworks such as Intervention Mapping [68], Logic Modeling [69], and the Behavior Change Wheel [67] offer systematic, theory-driven approaches that could enhance intervention effectiveness, particularly for parents. These frameworks help identify behavioral determinants, such as knowledge and self-efficacy, and tailor strategies to address them, potentially leading to stronger intervention effects. By focusing on specific determinants, these frameworks ensure precision and alignment with the needs of target groups, such as addressing parental barriers to engagement or motivation. However, their implementation poses challenges, especially for teams with limited capacity or funding, as they require significant time, expertise, and resources. While these frameworks have the potential to improve parental engagement and intervention outcomes, their application must be adapted to balance benefits with resource constraints.

By integrating theoretical frameworks, and addressing the challenges faced in intervention implementation, we can enhance the effectiveness of strategies aimed at promoting PA among adolescents. Future research should continue to focus on these areas to ensure that interventions to support adolescents' PA levels are both impactful and sustainable.

Conclusions

This study highlights the importance of perceived need-support from both PE teachers and parents in fostering adolescents' motivation towards leisure-time PA. Our findings indicate that when adolescents perceive higher levels of need-support, they demonstrate increased autonomous motivation, which subsequently enhances their attitude, intention, and effort towards engaging in leisure-time PA.

The web-based need-supportive interventions developed for PE teachers and parents were designed to equip these key social agents with strategies to support adolescents' basic psychological needs—autonomy, competence, and relatedness. While the web-based intervention for PE teachers effectively fostered significant changes in motivational constructs, the parental intervention did not yield the expected direct effects. This suggests that the effect of parental support may be more complex and less immediately observable compared to that of teachers.

Furthermore, the study underscores the importance of a cohesive approach where both educators and parents collaborate to create need-supportive environments for adolescents. Future research should aim to refine parental interventions and utilize objective measures of PA to better assess impacts. Overall, this study contributes to the understanding of how need-supportive contexts can promote healthier behaviors among adolescents.

Abbreviations

PA	Physical activity
PE	Physical education
WHO	World Health Organization

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-025-22590-x.

Supplementary Material 1

Supplementary Material 2

Acknowledgements

Not applicable.

Author contributions

AK, HT and PRM designed the study. PRM, AK and HT developed the intervention. PRM drafted the manuscript. AK and HT edited the manuscript and approved the final version prior to submission.

Funding

This work was supported by the University of Tartu, Institute of Sport Sciences and Physiotherapy. The project has not received external funding.
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Data availability

The datasets generated during and analyzed during the current study are available in the Open Science Framework (OSF) repository https://doi.org/10.17605/OSF.IO/EF38P. The repository includes all relevant data necessary to replicate the analyses and findings presented in this study.

Declarations

Ethics approval and consent to participate

Ethical approval for this study was provided by the Research Ethics Committee of the University of Tartu (code: 327/T-4, 19.10.2020). Children and parents provided informed written consent to participate in the study. All methods were performed in accordance with the relevant guidelines and regulations.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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Received: 1 November 2024 / Accepted: 2 April 2025
Published online: 10 June 2025

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