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ARTICLE

Online Intervention Program Based on Need-Supportive Activities to Promote Physical Activity and Cognitive Functions in Physical Education

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Purpose: We analyzed the effect of need-supportive activities intervention on students' psychological needs, motivation, physical activity behaviors, and cognitive functions in online physical education during the COVID-19 outbreak. ***Method:*** A total of 495 secondary students (M_{age} = 15.54, standard deviation = 1.05, females = 50.7), and eight physical education teachers (ages ranging from 26 to 38 years old) participated in this quasi-experimental research. The present study featured two conditions: need-supportive activities intervention experimental and no-intervention control conditions, and measurements were taken at three time points. ***Results:*** Compared with students in the control condition, students in the experimental condition reported higher autonomous motivation (T2: MΔ = 0.28, p = .006; T3: MΔ = 0.27, p = .02) and cognitive function (T2: MΔ = 0.27, p = .01; T3: MΔ = 0.26, p = .03) and lower amotivation (T2: MΔ = –0.32, p = .03; T3: MΔ = –0.40, p = .02), but we did not find differences on need satisfaction, need frustration, controlled motivation, and physical activity behaviors between the two conditions (p > .05). ***Conclusion:*** The findings showed that the need-supportive activities intervention could help students remain motivated toward activities during their leisure time and improve their cognitive functions in physical education.

Keywords: interpersonal style, motivation, teachers' behaviors, out-of-school physical activity

There is no doubt that technology has benefits in physical education (PE) programs, and if it is used effectively by both teachers and students, it can result in positive health and education outcomes (SHAPE America, 2018). Online PE programs would provide meaningful experiences to enhance students' lifelong patterns of health and well-being (Daum, 2020). Research has shown that online PE programs enhance students' positive outcomes (Williams et al., 2020). Also, research conducting during the emergence of the new coronavirus has found that adolescents' physically active lifestyles dramatically decreased in many countries (Park et al., 2022). To address such inactive behaviors, online PE programs have been suggested as an effective intervention to help adolescents remain physically active during these difficult circumstances (Webster et al., 2021). Moreover, lower levels of PA and limitation in movement not only relate to the risk of unhealthy behaviors but also might relate to impairment in cognitive functions (Ingram et al., 2021). Cognitive functions contribute to students' success in school (St Clair-Thompson & Gathercole, 2006) and teachers' interpersonal behaviors as an important determinant of students' behaviors would relate to the development of their cognitive abilities (Sosic-Vasic et al., 2015). However, these important factors received little attention in online PE and during the COVID-19 circumstances, especially how teachers' behaviors would help students to stay physically active and develop their cognitive functions in online lessons.

Younger students might struggle to motivate themselves to pursue healthy behaviors during restrictions in online programs (e.g., Behzadnia et al., 2022) compared with older students that can take responsibility to self-manage their psychological needs and motivate themselves toward healthy behaviors (Behzadnia & FatahModares, 2020). To motivate students toward healthy behaviors in online classes during restrictions, we applied a self-determination theory approach (SDT; Ryan & Deci, 2017). We delivered activities to support and satisfy students' basic psychological needs (viz., autonomy, competence, and relatedness; Behzadnia & FatahModares, 2020) through a need-supportive teaching approach (Ntoumanis et al., 2021) in online PE programs. Therefore, we aimed to examine the effect of an intervention based on need-supportive activities intervention (NSAI) on students' need-based experiences, motivational regulations, PA behaviors, and cognitive functions in an online PE semester.

Based on SDT (Ryan & Deci, 2017), all human beings have three basic psychological needs for autonomy (sense of volition and decision making), competence (feeling of mastery and capability in doing things), and relatedness (sense of positive and significant relationship with others). Research has shown that the satisfaction of these three basic needs is an essential nutrient for healthy behaviors and well-being; whereas, need frustration results in negative outcomes, such as ill-being, and disengagement (Vasconcellos et al., 2020). From an SDT perspective, social contexts would determine satisfaction versus frustration of basic needs. PE teachers would create a need-supportive environment by providing students with choice and decision making (autonomy support) and informative and positive feedback (competence support) and recognizing the expression of negative affects (relatedness support). In contrast, teachers' need-thwarting behaviors refer to the use of controlling behaviors, or pressuring students to behave in the prescribed ways (autonomy thwarting), using negative feedback (competence thwarting), and creating a cold class

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environment (relatedness thwarting; Ahmadi et al., 2023). Importantly, while supporting students' psychological needs would results in students' positive outcomes, it is important to avoid need-thwarting behaviors (Haerens et al., 2015, 2017). That is, supporting students' psychological needs should be applied simultaneously while diminishing their need-thwarting behaviors to result in students' positive outcomes (Leo, Mouratidis, et al., 2022).

Research before the COVID-19 pandemic has shown that students' PE positive (vs. negative) outcomes come from a dual model of the bright and dark sides of motivation. On the bright side, generally, teachers' need-supportive behaviors were related to students' need satisfaction and autonomous motivation (doing activities out of interest and enjoyment and personally valuing such actions); whereas, on the dark side, teachers' need-thwarting behaviors related to students' need frustration, controlled motivation (participating in activities to avoid a feeling of shame and guilt and prevent external pressures or to earn rewards), and amotivation (a lack of intention to do things) in PE programs (Leo, Behzadnia, et al., 2022). During the COVID-19 outbreak, research showed that teachers' need-supportive behaviors related to students' autonomous motivation; in contrast, need-thwarting behaviors related to students' amotivation in online PE (Behzadnia et al., 2022). Moreover, recent research has shown that web-based need-supportive intervention, where teachers can access prerecorded materials, tools, and resources asynchronously increased students' need satisfaction, and decreased their autonomy frustration over time, as well as diminished students' perceptions of teachers' controlling behaviors in PE programs (Tilga et al., 2019). Web-based need-supportive intervention programs has also been found to increased students' autonomy need satisfaction and diminished their autonomy need frustration (Tilga, Kalajas-Tilga, Hein, & Koka, 2021; Tilga, Kalajas-Tilga, Hein, Raudsepp, & Koka, 2021). Interestingly, research has shown that when web-based intervention is combined with face-to-face intervention, it resulted in students' greater need satisfaction compared with only provided web-based or face-to-face need-supportive intervention (Tilga, Kalajas-Tilga, Hein, & Koka, 2021). That implies the importance of web-based intervention; though when it is possible, it can be more effective for students to provide face-to-face intervention, that also results in students' greater need satisfaction, and intrinsic motivation.

In addition to the effects of social contexts in students' need-based experiences (need satisfaction vs. frustration), research has also shown that when individuals engage in the activities that they experience need satisfaction, it relates to their intrinsic motivation and greater well-being (Behzadnia & FatahModares, 2020; Weinstein et al., 2016). Research by Behzadnia and FatahModares (2020) showed that NSAI through an online platform (WhatsApp mobile application) helped participants to enhance their need satisfaction, autonomous motivation, and well-being and reduce their need frustration, amotivation, and psychological stress during the COVID-19. The NSAI included activities, such as encouraging participants to decide to pursue healthy behaviors, and try to do joyful exercises. The NSAI approach would prompt individuals to self-directing need-supportive activities that not only help them to experience higher need satisfaction but also to help them to find motivational reasons to continue activities when they are not in the class/school environment (Behzadnia & FatahModares, 2020, 2023). NSAI does not imply that social context is not important; it means that students are encouraged to do the activities together. Rather than an external person (like a teacher), adolescents are encouraged to influence their own social contexts. In NSAI, teacher supports students' psychological needs in the form of activities—that is, teacher proposes and encourages students to do these need-supportive activities. From an organismic perspective, psychological needs either implicitly or explicitly direct individuals' actions and lead them to proactively seek out activities that bring them need satisfaction. Moreover, psychological needs play a directional role in pulling individuals into actions that implicitly experience higher need satisfaction and prevent them from negative feelings (see Vansteenkiste et al., 2020). In addition, individuals have the propensity to regulate their own psychological needs, and learning about needs would attentive them toward activities that are need-conductive and help them to be more aware of how to create or support their own needs (Laporte et al., 2022; Vansteenkiste et al., 2023). Thus, it might be that when students feel they can behave in ways that they truly choose by themselves (autonomy), believe that they can do things effectively (competence), and feel that they volitionally can make new/positive relationships with others (relatedness), they experience higher need satisfaction and diminish their need deprivation (Behzadnia & FatahModares, 2020, 2023). To deliver NSAI, teachers are needed to behave in a need-supportive way, such as support students' decision making (Cheon et al., 2023). To help adolescents rely on inner resources, take responsibility for their behaviors, and create a need-supportive environment for themselves, teachers first need to behave in a need-supportive way to provide opportunities for students to act in such autonomous actions (Laporte et al., 2021).

Previously, teachers' need-supportive behaviors on students' leisure-time physical activity have been found to help students enhance their quality of motivation to do out-of-school PA (Schneider et al., 2020). So, teachers can provide support for students' motivation during PE classes (Leo, Behzadnia, et al., 2022) but can also be influential in promoting motivation toward PA in their leisure time (Schneider et al., 2020), which might help students to increase their out-of-school PA levels (Polet et al., 2020). The NSAI might also facilitate students' motivation toward out-of-school activities, and to add to the benefits of a need-supportive teaching approach, students would benefit from the NSAI when teachers provide this for them.

In this study, we intended to test a psychosocial intervention of NSAI (Behzadnia & FatahModares, 2020) in combination with need-supportive teaching (Cheon et al., 2023) on students' need-based experiences, motivations, PA behaviors, and cognitive functions in online PE lessons. In this study, we deliver the intervention (NSAI) in online PE—that is, the intervention was entirely online in real time, meaning both the teacher training and the PE classes with students were delivered synchronously in a fully virtual environment. Based on SDT (Ryan & Deci, 2017), we hypothesized that students in the experimental condition (NSAI) would increase their need satisfaction, autonomous motivation, PA behaviors, and cognitive functions more than students in the no-intervention control condition (H1). Also, we hypothesized that students in the experimental condition would decrease their need frustration, controlled motivation, and amotivation than students in the control condition (H2). We also tested a dual model of the bright and dark sides of motivation. We expected that the experimental condition (NSAI) over a semester not only increase students' need satisfaction, autonomous motivation, PA behaviors, and cognitive functions at both middle (T2) and end of the semester (T3) but also decrease students' need frustration, controlled motivation, and amotivation at both T2 and T3. Therefore, we tested whether NSAI-induced increases in T2 need satisfaction and

autonomous motivation predict longitudinal increases in T3 students' PA behaviors and cognitive functions (H3a). We also tested whether NSAI-induced decreases in T2 need frustration, controlled motivation, and amotivation positively predict longitudinal increases in T3 students' PA behaviors and cognitive functions (H3b).

Method

Participants and Procedures

A sample of 495 students (M_{age} = 15.54, standard deviation = 1.05, females = 50.7%) aged ranging from 13 to 17 years old took part in this quasi-experimental research design by filling in a set of questionnaires in September 2021 (beginning of the first semester [T1]) during the COVID-19 outbreak. These students were enrolled in eighth (n = 33), ninth (n = 9), 10th (n = 213), 11th (n = 137), and 12th (n = 103) grades. Students filled out the study questionnaire three times during the course of an online semester, during the second year of the COVID-19 outbreak: beginning of the first semester (T1), middle of the semester (T2), and at the end of the semester (T3; see Figure 1). The University of Tabriz Research Ethics Committees approved the study protocol.

Two weeks before the beginning of the study (T1), we asked 10 certified PE teachers (ages ranged from 26 to 38 years old, female = 5) with an average of 2.5 years of PE teaching experience in school to participate in this study. The selection of teachers was through a convenience sampling method, and all of the invited teachers agreed to participate. They were randomly allocated into either experimental (NSAI, n = 5) or no-intervention control conditions (n = 5). However, two of the teachers who were allocated to the experimental condition did not follow the programs so we could not collect data from their students (n = 60, the final teachers in the experimental condition = 3). Teachers who agreed to participate confirmed that their students have access to the online tools (Shad mobile application programs to attend online PE programs in Iran) and would fill out the questionnaires three times over a semester. Before starting the data collection and delivering the intervention to the teachers in the experimental condition, two separate groups in WhatsApp were created for teachers in each condition by a research assistant. Teachers used Shad mobile application program for contacting and delivering programs that were organized and created by the Ministry of Education (similar to Adobe Connect and Zoom) to students during the COVID-19 outbreak. The questionnaires were created in Google Docs, and the link was sent to students by their teachers through Shad mobile application. Students in both conditions were informed that the study aims to investigate their psychological status in PE programs in general, and their responses are confidential and anonymous.

Measures

Teacher Behaviors

Students' perceptions of teachers' need-supportive and need-thwarting behaviors were measured through the interpersonal behaviors questionnaire (IBQ; Rocchi et al., 2017). Similar to previous research, the stem of IBQ slightly adjusted to the PE domain during online programs: "With respect to my virtual PE lessons, my teacher ...." The IBQ includes 24 items, and each need-based behavior was assessed by four items: autonomy support (e.g., "Support my decisions"), autonomy thwarting (e.g., "Pressure me to do things their way"), competence support (e.g., "Encourage me to improve my skills"), competence thwarting (e.g., "Point out that I will likely fail"), relatedness support (e.g., "Is interested in what I do"), and relatedness thwarting (e.g., "Does not connect with me"). The scale ranged from 1 (*Strongly disagree*) to 7 (*Strongly agree*). In this study, we measured a composite of need support and need thwarting by averaging their corresponding three needs. Internal consistently as measured through Cronbach's alpha and omega were acceptable for need support (α = .92; ω = .92), and need thwarting (α = .79; ω = .82). The IBQ has previously been employed in Iranian samples (Behzadnia, 2021).

Basic Psychological Needs

Students' experience of need satisfaction and frustration were measured through the 12-item Persian short version (Behzadnia et al., 2018) of the Basic Psychological Need Satisfaction and Need Frustration Scale (Chen et al., 2015). The stem of Basic Psychological Need Satisfaction and Need Frustration Scale slightly adjusted to the online PE: "In virtual PE programs, I experienced ...." Each need was assessed by two items: autonomy satisfaction (e.g., "I felt that the activities reflect what I really want"), autonomy frustration (e.g., "I felt forced to do many activities I would not choose to do"), competence satisfaction (e.g., "I felt confident that I could do the exercises well"), competence frustration (e.g., "I felt insecure about my abilities"), relatedness satisfaction (e.g., "I felt close and connected to the class members who are important to me"), and relatedness frustration (e.g., "I felt excluded from the group I want to belong to"). The scale ranged from 1 (*Not all true*) to 5 (*Completely true*). In this study, we measured a composite of need satisfaction and need frustration by averaging all corresponding three needs. Internal consistency, measured through Cronbach's alpha and omega was nearly acceptable for need satisfaction (α = .67; ω = .67) and need frustration (α = .61; ω = .62). These reliability values are in line with previous studies conducted by Behzadnia et al. (2018) for need satisfaction, and Behzadnia et al. (2022) for need frustration.

Motivational Regulations Toward PA

Students' types of motivation toward PA were assessed through Behavioral Regulation in Exercise Questionnaire-2 (BREQ-2; Markland & Tobin, 2004). The instruction to the BREQ-2 was "I engage in physical activities because ...." The BREQ-2 assessed three types of motivation, namely autonomous motivation (eight items, e.g., "I exercise because it's fun"), controlled motivation (seven items, e.g., "I exercise because others will not be pleased with me if I don't"), and amotivation (four items, e.g., "I think exercise is waste of time"). The scale ranged from 0 (*Not true for me*) to 4 (*Very true for me*). The BREQ-2 has previously been employed in Iranian samples (Farmanbar et al., 2011). Internal consistently through Cronbach's alpha and omega were acceptable for autonomous motivation (α = .88; ω = .89), controlled motivation (α = .78; ω = .79), and amotivation (α = .81; ω = .81).

Cognitive Functions

Students' cognitive functions was assessed through the Cognitive Abilities Questionnaire (Nejati, 2013). The scale included 30 items assessing selective attention and inhibitory control (e.g., "Learning new things is difficult"), memory (e.g., "Remembering the things that I want to do is difficult"), social cognition (e.g., "It is important for me that others listen to me"), planning (e.g., "I don't have long-term planning for my works"), decision making (e.g., "I prefer to do things rapidly rather than accurately do them"), sustain attention

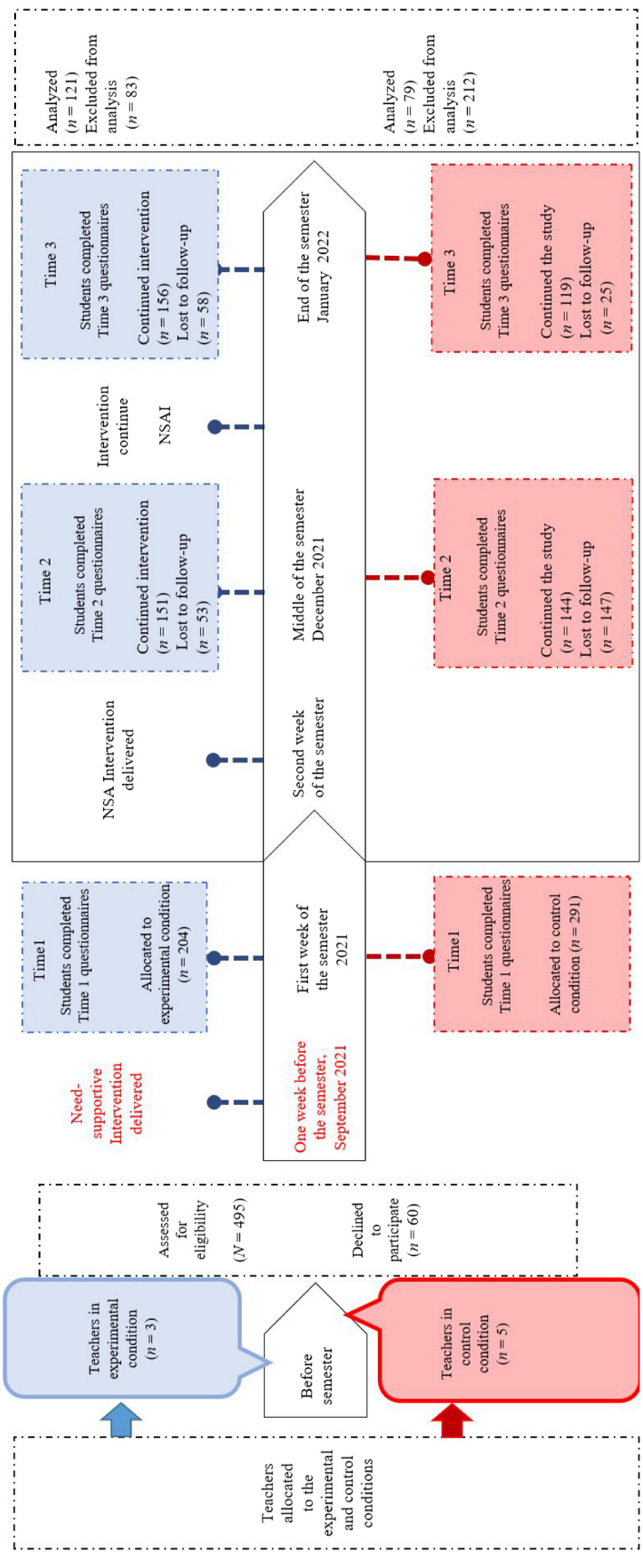

Figure 1 — CONSORT—Study timeline. NSAI = need-supportive activities intervention.

(e.g., "It is difficult to completely listen to a lecture"), and cognitive flexibility (e.g., "I cannot focus on a subject more than ten minutes") in Iranian samples. The scale ranged from 1 (*Never*) to 5 (*Always*). In this study, we measured a composite of cognitive function ($\alpha = .90$; $\omega = .91$) by averaging all items.

PA Behavior

Students' PA behavior was measured through the short seven generic items version of the International Physical Activity Questionnaire (Craig et al., 2003). The International Physical Activity Questionnaire measures the level of PA behaviors during "the last 7 days." The International Physical Activity Questionnaire assesses vigorous-intensity PA, moderate-intensity PA, walking, and time spent sitting, and each of these measures in days, hours, and minutes, separately. General PA behavior was measured by calculating PA in minutes per week and has been previously employed in the Iranian samples by BashiriMoosavi et al. (2015).

Demographic Information

Students' age, gender (male and female), grade (eight to 12), COVID-19 background (infected with COVID-19 or not), and socioeconomic status (SES) were collected. The MacArthur Scale of Subjective Social Status (Adler et al., 2000) was used to assess participants' SES through a numbered stepladder image. Participants needed to choose one step that best showed where they were located in their social community based on their occupation, income, and education, ranging from 1 (*lowest level: step*) to 10 (*highest level: step*).

Manipulation Checks and Procedure of Intervention (NSAI)

The present study featured two conditions: NSAI experimental condition and no-intervention control condition. The procedural timeline for the intervention and data collection across three waves appears in Figure 1. To assess the effectiveness of the NSAI in online PE programs, we focused on two manipulation checks. . First, we assessed students' perceptions of need-supportive and need-thwarting behaviors, as well as their experience of need satisfaction and need frustration over three times. Next, feedback was provided for teachers either in terms of teachers' interpersonal behaviors (need support and need thwarting) or in terms of the application of NSAI in PE.

Teachers in the experimental condition participated in two intervention workshops (each workshop = 1.5 hr), delivered by the first author. Workshops were held online, and to response to teachers' questions at any time, they could ask their questions in the WhatsApp groups where the first author was also a member. The workshops were recorded for teachers' use and sent to the teachers in the experimental condition via WhatsApp so they can use it whenever they needed. That is, along with PE lessons in virtual programs, teachers in the experimental condition tried to behave in a need-supportive teaching way (and also reduce need-thwarting behaviors) and deliver the NSAI to students. Teachers in the control condition taught their usual lessons through the Shad mobile application during the COVID-19.

Part 1 of the workshop took place a week before the semester began. It included three sections that introduced the importance of students' healthy behaviors during lockdowns and how their current instructions would relate to students' healthy behaviors. The next part introduced the meaning of three basic psychological needs, why they are important, and practical examples of how teachers can create a need-supportive climate in PE programs. At the same time, the negative sides of need-thwarting behaviors were discussed. In this part, the efficacy of need-supportive behaviors and reducing need-thwarting behaviors based on previous research were also discussed. The instruction on how to create a need-supportive environment was based on previous research in PE programs (Cheon et al., 2023; e.g., Vasconcellos et al., 2020). This first part of the intervention aimed to help teachers learn about the concept, and importance of basic psychological needs, and how teachers can support these needs. That is, as teachers were not familiar with the concept of basic psychological needs, this part was used to try to help teachers learn how to support students' needs to follow the PE activities through online programs. Moreover, we asked teachers to do their general activities in the first week of the school semester, such as introducing PE in online programs and not acting based on the need-supportive behaviors intervention. Students were also asked to fill out the questionnaires at the end of the first day of online PE programs.

The next and main part of the intervention introduced NSAI in PE activities at the beginning of the second (first week of October) week of school programs (Behzadnia & FatahModares, 2020). It included four main sections: (a) encourage students to do purposeful physical activities at home, (b) encourage students to do creative activities during and after PE programs and provide positive feedback, (c) plan grouping activities for students to enhance their relationship with other classmates, (d) creating challenging activities for students at home, and (e) write their positive thoughts about the program (Table 1). Moreover, sample and instructional scripts for each of the basic need activities and corrective feedback were provided for teachers.

In this part of the intervention, the main goal was that teachers would allow students to take responsibility for their activities. Somewhat similar to the intrinsic instructional goal intervention (Jang & Reeve, 2021), teachers, for example, provided choices with students to do the activities based on their preferences, encouraged them to do the activities together, and encouraged them to learn new things but not explicitly direct them as to what to do, and how to do the activities. Teachers needed to introduce activities during online PE and encourage students' creative behaviors based on the main PE structures and need-based activities. The goal of this approach was to help students learn how to take responsibility for their actions and how to create supportive environments for themselves. Teachers then provided feedback on students' activities and helped them to do the activities but were not given explicit directions on how to do them.

The virtual PE programs during the COVID-19 included physical fitness activities with the main aim of enhancing their physical well-being. Teachers provided either live or recorded PE lessons once a week for 16 weeks (a semester). That is, each session length was 90 min, and it included PE activities, such as warm-up activities (15 min), physical fitness (e.g., push-up and curl-up, 45 min), and cool-down exercises (10 min; see Behzadnia et al., 2022).

Data Analysis

Data were first screened for outliers. We found 15 outliers (they were harmonically rated scales, such as they chose only five, or only one for all questions, $n = 5$), and some of them included missing values. After removing them, the final sample resulted in 495 participants. The univariate normality of data was assessed through skewness (ranging from −1.53 to 1.80) and kurtosis (ranging from −0.38 to 3.88).

Table 1 Sample Scripts in the NSAI Condition in a Need-Supportive Way

Basic needs activities	Sample scripts
Encourage students to do physical activities purposefully at home	Teachers encourage students to make their PE activities purposefully such as make a plan to do physical activity at least two times per week rather than only rely on the main session of PE activities per week. Teachers encouraged students to make a plan for this, even less than the recommended physical activities (e.g., 30 min) or during weekends. To do so, according the general physical activities guidelines that teachers provided for them during virtual programs, they provided students with choice and options on how to do these and asked them to make decision by themselves. They encourage to learn as simple and small as new skills even with limitation in sport equipment, and tried to be creative in doing them. Innovation in physical activities were encouraged. They were are encouraged to make new sport equipments, such as creating dumbbells with bottles, as well as try to share their idea with other students.
Organize grouping activities for students to enhance their relationship with other classmates	Teachers encourage students to do grouping activities (create specific groups for students in Shad app), such as using video call when exercising. They were also encourage to ask their family members to accompany them in doing exercise. They needed to report their physical activity programs in groups, and students reported their experiences during grouping activities.
Create challenging activities for students at home	Teachers encourage students to do challenging activities, such as doing specific skills or make a new record in push-up or squat and compare their progress with their first record at the beginning of the semester. They would create activities to experience greater enjoyment; at the same time, they were responsible for those activities at the PE activities. To do so, teachers encourage students' explanatory behaviors and help them with new techniques, as well as asked students preferences and approaches in doing these and tried to intrinsically engage them at the activities. At the end of activities, students needed to write their activities and send it their teachers.
Encourage students to do creative activities during and after PE programs and provided positive feedback, even if it was so small	To encourage students to do physical activities, teachers used positive dialogues and provided positive feedback in their activities, such as "gratitude," and "you did a great job." This is important when students are doing their activities in groups. Teachers also encourage students to do happy and fun activities, such as smiling when doing the activities. They are also suggested to do such happy activities with other group and family members, and tried to energize their positive others to help them engage at the activities.
Write their positive thoughts about the program	At the end of the semester, teachers asked students to write their positive experiences and thoughts about these activities during the semester. They also needed to share these experiences with others. Also, they would write the effect of these activities on their purpose and meaning in life and share it with their important people in life.

Note. PE = physical education; NSAI = need-supportive activities intervention.

To test the effectiveness of the NSAI on students' outcomes (Hypotheses 1 and 2), we conducted 2 (experimental and control conditions) × 3 (times of assessment) repeated-measures analyses of covariance (covariates: students' grade, age, gender, SES, and COVID-19 background) for each variable separately in SPSS (version 24). The experimental and control conditions served as the first independent between-groups variable, and three times of assessment served as within-groups repeated measures as the next independent variable. To prevent multiple test problems and the inflation of Type I error, we employed Holm's sequential Bonferroni t test in pairwise comparisons. In addition, before testing the main hypotheses, power analysis for two conditions repeated measures was computed in G*Power 3.1.9.2 (Faul et al., 2007). With an expected medium effect size of $d = 0.40$ (Cohen's d), power = 0.95, and $p = .05$ among a set of seven variables (plus five covariates), power determined the total sample size of 162 is needed. The T1 sample size was 495, so we determined that the study has sufficient participants to test the hypotheses. To test Hypothesis 3, we stipulated a path from condition (experimental code = 1 and control code = 0) toward need satisfaction and need frustration at T2. We also assumed direct paths from T2 need satisfaction and frustration toward T3 autonomous and controlled motives and amotivation, as well as direct paths from T2 autonomous and controlled motives, and amotivation toward T3 PA behaviors and cognitive functions. Moreover, for all variables at T2 and T3, we stipulated a direct path from their corresponding score at T1 and T2, respectively (e.g., from T1 need satisfaction to T2 need satisfaction and from T2 need satisfaction to T3 need satisfaction). In addition, for all variables at T3, we stipulated a direct path from their corresponding baseline score (T1; e.g., from T1 need satisfaction to T3 need satisfaction). To do this, a path analysis with full information maximum likelihood in conjunction with bootstrapping (bootstrap = 5,000) and 95% of confidence intervals (CIs) was conducted in Mplus 7.4 (Muthen & Muthen, 2012), which also effectively accounts for missing values.

Results

Before testing the main hypotheses, through multivariate analyses of variance, we examined the differences between persistent and

dropout students. At T1, 495 students completed all questionnaires across both conditions. At T2, 295 students completed the questionnaires, while 200 students did not. The T2 dropout students only scored lower on the T1 PA level than the persistent students, but they did not differ in the remaining variables. At T3, 275 students completed all questionnaires, while 20 of the T2 remaining students did not. The T3 dropout students reported lower autonomous motivation, controlled motivation, and PA levels at T1 than the remaining students in the experimental condition, but they did not differ in the remaining variables. In addition, T3 dropout students also reported lower perceived need support, need satisfaction, autonomous motivation, controlled motivation, and PA levels at T2 than the remaining students in the experimental condition.

Of the 495 students, missing data were rare (<.01%) and were handled using multiple imputation methods. To address potential bias from attrition (retention rate = 40.4%), we applied Little's (1988) test of missing completely at random, which indicated that the attrition was completely random ($\chi^2[249] = 219.74$, p = ns). At T3, 275 students completed the questionnaires; however, 75 of these students had not completed the questionnaires at T2. Therefore, the final sample for repeated-measures analyses included 200 students: 121 in the experimental condition (12 females, 9.9%, and 109 males, 90.1%), and 79 in the control condition (65 females, 82.3%, and 14 males, 17.7%). Given the unequal group sizes, we verified the assumption of equality of variances using Levene's test.

Participants' demographic information, descriptive statistics, and intercorrelation between variables appear in Appendix. Primarily analyses showed that age, SES, gender (female code = 1, male code = 2), grade, and COVID-19 background related to the study variables at baseline. Given these findings, in the main analyses, we controlled for students' age, SES, gender, grade, and COVID-19 background.

For *students' perceptions of teachers' need-supportive behaviors*, the results showed the main effect for time, $F(1.91, 367.80) = 3.15$, $p = .04$, $\eta_p^2 = .02$, but the main effect for condition, $F(1, 193) = 2.90$, $p = .09$, $\eta_p^2 = .02$, and the main effect for the interaction of Time × Condition, $F(1.91, 367.80) = 2.55$, $p = .08$, $\eta_p^2 = .01$, were not significant. As illustrated in Figure 2a, perceived need support remained unchanged in the experimental condition from T1 to T2, from T1 to T3, and from T2 to T3; whereas, it also remained unchanged in the control condition from T1 to T2, from T1 to T3, and from T2 to T3. The two conditions did not differ at T1, T2, and T3.

For *students' perception of need-thwarting behaviors*, none of the main effect for time, $F(1.94, 374.30) = 0.21$, $p = .80$, $\eta_p^2 = .00$; the main effect for condition, $F(1, 193) = 3.33$, $p = .07$, $\eta_p^2 = .02$; and the main effect for the interaction of Time × Condition, $F(1.94, 374.30) = 0.17$, $p = .84$, $\eta_p^2 = .00$, were significant. Therefore, we did not examine changes over time and comparisons.

For *students' need satisfaction*, the main effect for condition, $F(1, 193) = 9.33$, $p = .003$, $\eta_p^2 = .05$, was significant, but the main effect for time, $F(2, 192) = 0.89$, $p = .41$, $\eta_p^2 = .01$, and the interaction of Time × Condition, $F(2, 192) = 0.20$, $p = .82$, $\eta_p^2 = .00$, were not significant. As illustrated in Figure 2c, need satisfaction remained unchanged in the experimental condition from T1 to T2, from T1 to T3, and from T2 to T3; whereas, it also remained unchanged in the control condition from T1 to T2, from T1 to T3, and from T2 to T3. While the two conditions did not differ at T1, need satisfaction for the students in the experimental condition was higher than it was for the students in the control condition at T2 ($M\Delta = 0.21$, $p = .04$, $d = 0.32$, 95% CI [0.00, 0.41]) and at T3 ($M\Delta = 0.25$, $p = .04$, $d = 0.36$, 95% CI [0.01, 0.49]).

For *students' need frustration*, the main effect for condition, $F(1, 193) = 8.84$, $p < .003$, $\eta_p^2 = .04$, was significant, but the main effect for time, $F(2, 192) = 0.91$, $p = .40$, $\eta_p^2 = .01$, and the interaction of Time × Condition, $F(2, 192) = 0.03$, $p = .97$, $\eta_p^2 = .00$, were not significant. As illustrated in Figure 2d, need frustration remained unchanged in the experimental condition from T1 to T2, from T1 to T3, and from T2 to T3; whereas, it also remained unchanged in the control condition from T1 to T2, from T1 to T3, and from T2 to T3. While two conditions did not differ at T1 and at T3, need frustration for the students in the experimental condition was lower than it was for the students in the control condition at T2 ($M\Delta = -0.33$, $p < .004$, $d = 0.46$, 95% CI [−0.55, −0.11]).

For *students' autonomous motivation*, the main effect for time, $F(2, 192) = 0.21$, $p = .81$, $\eta_p^2 = .00$, and the main effect for the interaction of Time × Condition, $F(2, 192) = 1.16$, $p = .32$, $\eta_p^2 = .01$, were not significant, but the main effect for condition, $F(1, 193) = 3.97$, $p = .048$, $\eta_p^2 = .02$, was significant. As illustrated in Figure 2e, autonomous motivation remained unchanged in the experimental condition from T1 to T2, from T1 to T3, and from T2 to T3; whereas, it decreased from T1 to T2 ($M\Delta = 0.30$, $p < .005$, $d = 0.35$, 95% CI [0.07, 0.52]), and from T1 to T3 ($M\Delta = 0.30$, $p < .003$, $d = 0.36$, 95% CI [0.09, 0.52]), but remained unchanged from T2 to T3, for students of the teachers in the control condition. Students in the experimental condition reported higher autonomous motivation than students in the control condition at T1 ($M\Delta = 0.14$, $p = .04$, $d = 0.29$, 95% CI [0.00, 0.28]). The results showed that students in the experimental reported higher autonomous motivation than students in the control condition at T2 ($M\Delta = 0.28$, $p = .006$, $d = 0.37$, 95% CI [0.08, 0.48]) and at T3 ($M\Delta = 0.27$, $p = .02$, $d = 0.65$, 95% CI [0.04, 0.50]) after controlling for T1 autonomous motivation.

For *students' controlled motivation*, none of the main effect for time, $F(1.93, 372.34) = 1.54$, $p = .22$, $\eta_p^2 = .01$; the main effect for condition, $F(1, 193) = 1.22$, $p = .27$, $\eta_p^2 = .01$; and the main effect for the interaction of Time × Condition, $F(1.93, 372.34) = 0.35$, $p = .70$, $\eta_p^2 = .00$, were significant. Therefore, we did not do further analyses to examine changes over time and comparisons.

For *students' amotivation*, the main effect for condition, $F(1, 193) = 5.87$, $p = .02$, $\eta_p^2 = .03$, was significant, but the main effect for time, $F(2, 192) = 2.05$, $p = .13$, $\eta_p^2 = .02$, and the interaction of Time × Condition, $F(2, 192) = 1.93$, $p = .15$, $\eta_p^2 = .02$, were not significant. As illustrated in Figure 2g, amotivation remained unchanged in the experimental condition from T1 to T2, from T1 to T3, and from T2 to T3; whereas, it also remained unchanged in the control condition from T1 to T2 and from T2 to T3, but it increased from T1 to T3 ($M\Delta = -0.25$, $p = .04$, $d = 0.29$, 95% CI [−0.55, −0.01]). The two conditions did not differ at T1, but students in the experimental condition reported lower amotivation than students in the control condition at T2 ($M\Delta = -0.32$, $p = .03$, $d = 0.36$, 95% CI [−0.61, −0.04]) and at T3 ($M\Delta = -0.40$, $p = .02$, $d = 0.41$, 95% CI [−0.74, −0.06]).

For *students' cognitive functions*, the main effect for condition, $F(1, 193) = 10.40$, $p < .001$, $\eta_p^2 = .05$, was significant, but the main effect for time, $F(2, 192) = 1.05$, $p = .35$, $\eta_p^2 = .01$, and the interaction of Time × Condition, $F(2, 192) = 1.83$, $p = .16$, $\eta_p^2 = .02$, were not significant. As illustrated in Figure 2h, cognitive function remained unchanged in the experimental condition from T1 to T2, from T1 to T3, and from T2 to T3; whereas, it also remained unchanged from T1 to T2 and from T2 to T3, but it decreased from T1 to T3 ($M\Delta = 0.15$, $p = .04$, $d = 0.22$, 95% CI [−0.31, −0.00] in

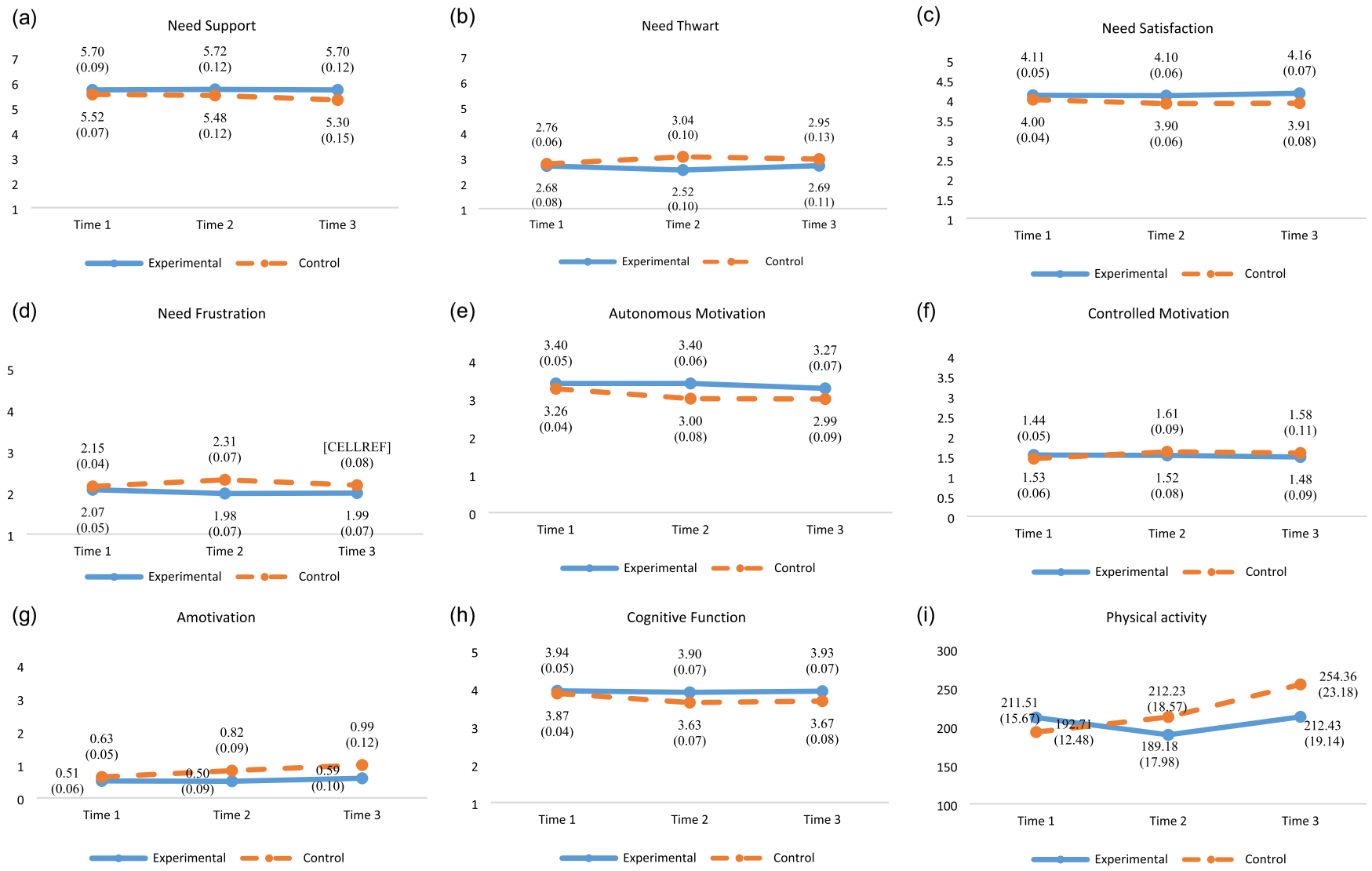

Figure 2 — Participants' experience of need support (a), need thwart (b), need satisfaction (c), need frustration (d), autonomous motivation (e), controlled motivation (f), amotivation (g), cognitive function (h), and physical activity (i). *Note*. Mean scores showed in figures are adjusted values based on the covariates (age, gender, grade, COVID-19 background, and SES). Values within parentheses are standard errors. SES = socioeconomic status.

the control condition. The two conditions did not differ at T1, but students in the experimental condition reported higher cognitive function than students in the control condition at T2 (MΔ = 0.27, $p = .01$, $d = 0.39$, 95% CI [0.05, 0.49]), and at T3 (MΔ = 0.26, $p = .03$, $d = 0.38$, 95% CI [0.02, 0.49]).

For *students' PA*, none of the main effect for time, $F(2, 165) = 0.75$, $p = .47$, $\eta_p^2 = .01$; the main effect for the interaction of Time × Condition, $F(2, 165) = 0.05$, $p = .96$, $\eta_p^2 = .00$; and the main effect for condition, $F(1, 166) = 0.03$, $p = .86$, $\eta_p^2 = .00$ were significant. Therefore, we did not do further analyses to examine changes over time and comparisons.

The hypothesized model yielded a good fit to data[1]: $\chi^2(123) = 282.88$, $p = .39$, comparative-fit index = .93, root mean square error of approximation = .05, 90% CI [0.04, 0.06], and standardized root mean square residual = .07 (Figure 3). After controlling for all covariates and baseline values of all variables, the model partially supported our hypothesis (H3). The results showed that experimental condition positively related to T2 autonomous motivation. T2 need satisfaction was positively related to T3 autonomous motivation and cognitive function. In contrast, T2 need frustration was related positively to T3 controlled motivation and T3 amotivation and related negatively to T3 cognitive function. With respect to the predictive roles of motivational regulations, only T2 amotivation was related positively to T3 PA behavior.

Discussion

Development of students' cognitive functions and enhancing their healthy behaviors are among the most important outcomes of PE activities (Donnelly et al., 2016). However, the new coronavirus challenged all educational programs and put adolescents' healthy behaviors at risk (Neville et al., 2022). Moreover, growing the use of technology and online programs in PE has some new challenges on how to motivate students to engage in the activities. In this study, based on SDT (Ryan & Deci, 2017), we delivered the NSAI (Behzadnia & FatahModares, 2020) to students during online PE programs with the main aims of enhancing their need satisfaction, autonomous motivation, PA behaviors, and cognitive functions and reducing their need frustration, controlled motivation, and amotivation.

Based on SDT (Ryan & Deci, 2017), we expected to see positive changes in students' need-based experiences. Unlike with previous research that used (mostly) college students (Behzadnia & FatahModares, 2020), we found that the experience of need

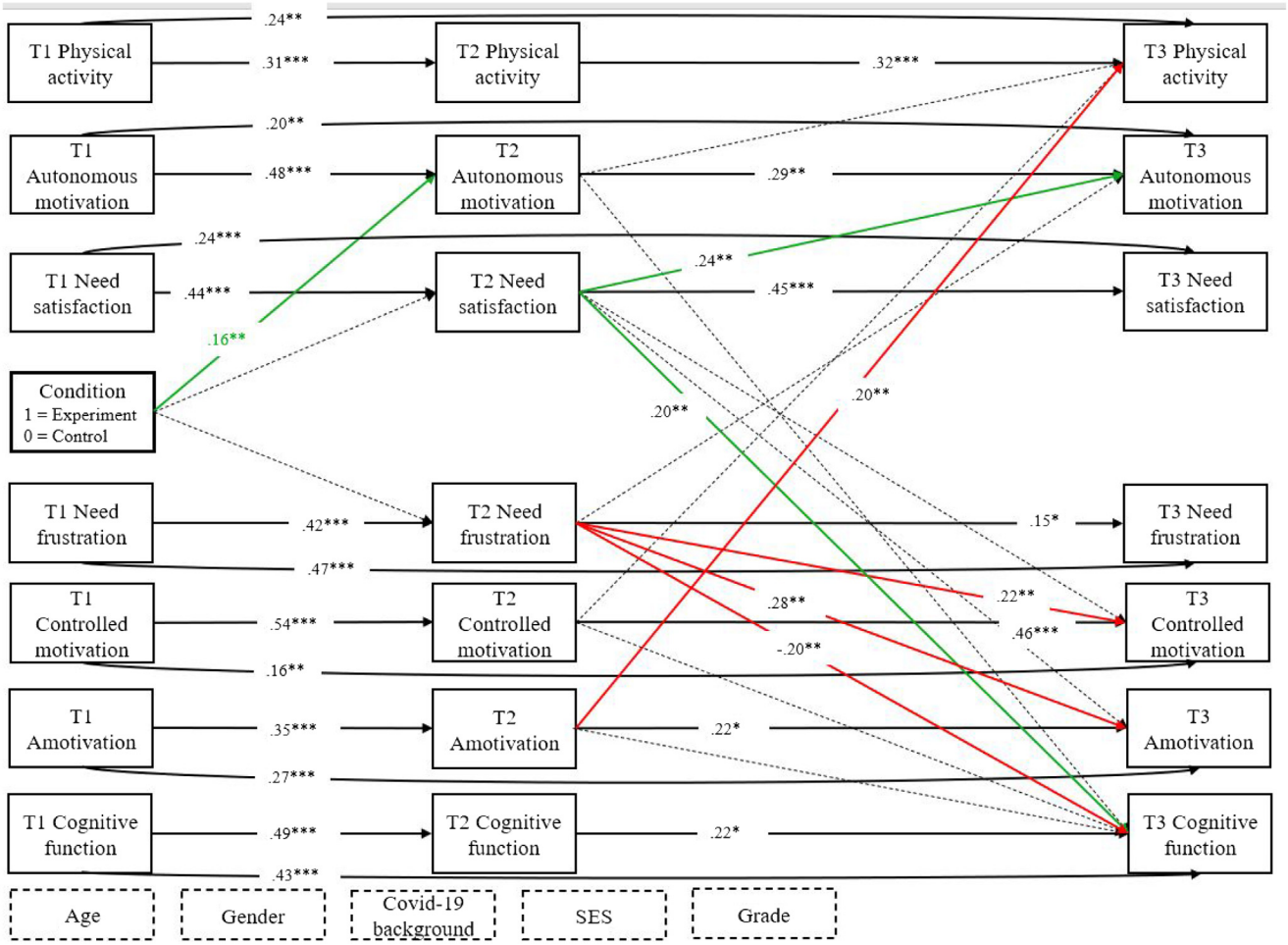

Figure 3 — Hypothesized model to examine the effect of need-satisfying activities on students' need satisfaction and frustration, motivational regulations, physical activity behaviors, and cognitive function over a virtual PE semester. *Note*. Dashed lines represent nonsignificant values. Standardized and significant estimates are reported. Correlation among variables and with covariates (age, gender, COVID-19 background, SES, and grade) are not shown due to the complexity of the model. PE = physical education; SES = socioeconomic status. $^*P < .05$. $^{**}P < .01$. $^*P < .001$.

satisfaction and need frustration did not change in students of the teachers in the experimental condition in online PE. Students' need satisfaction and frustration remained stable over time, and it seems the effects of NSAI and social contexts could not change students' need-based experiences. Importantly, the mean score of students' need satisfaction remained stable and at a high level across three time points in the experimental condition, and their need satisfaction was higher than students in the control condition. That is, the NSAI helped them to maintain their need satisfaction stable and at high levels, and need frustration remained in a low level across online programs.

While students in the control condition decreased their autonomous motivation and increased their amotivation, students' motivational regulations remained stable in the experimental condition over a semester during online PE. Previous longitudinal research has found that school students' autonomous and controlled motivations decreased, and amotivation remained unchanged (Behzadnia et al., 2022), but college students improved their autonomous motivation and amotivation results from online PE during the COVID-19 (Behzadnia et al., 2023). Importantly, the COVID-19 outbreaking stressful situation may affect negatively adolescents' quality of motivation toward healthy behaviors; however, the NSAI helped students to keep their motives unchanged. That is, students' autonomous motivation remained stable and at a high level, and their controlled motivation, and amotivation remained at lower levels in the experimental condition. This shows that online PE programs might decrease students' autonomous motivation and increase amotivation, but the NSAI at least maintained students' autonomous motivation. More interestingly, students' autonomous motivation was higher and their amotivation was lower than the students in the control condition.

Moreover, students' controlled motivation remained stable across conditions over a semester. It might be that students did not feel some external reasons to be motivated toward activities or feel that they are under pressure to behave in prescribed ways, as the results also did not show changes in their perceptions of their teachers' need-supportive and need-thwarting behaviors. Previous research has shown that students' introjected regulation would increase (Sparks et al., 2017) and external regulations and amotivation would decrease (Tessier et al., 2010) results from need-supportive behaviors in face-to-face PE programs; but, in the current study, we found that students' external contingents could not change over time either in the experimental or control condition during virtual PE lessons.

We also found that students' PA behaviors and cognitive functions did not change results from the NSAI program. Prior to the pandemic, one important way to help students enhance their healthy behaviors was to create a need-supportive environment (Vasconcellos et al., 2020)—however, it seems that the NSAI and virtual lessons hardly affect students' PA behaviors. It might be that students needed to access or be in the sports environments to affect their motives and enhance their PA behaviors, and this needs further research. Moreover, we found that students' cognitive function did not change in the experimental condition, though students of the teachers in the control condition decreased their cognitive function. While PA programs have been shown to be effective in promoting cognitive functions (e.g., Petruzzello et al., 1997), it seems that the NSAI through virtual PE programs could not increase students' cognitive function. Importantly, however, students in the experimental condition reported higher cognitive function than students in the control condition at T3, and this shows that the NSAI maintained students' cognitive functions over time. Moreover, we found that students' T2 need satisfaction positively contributed to their T3 cognitive functions.

In the hypothesized model, we found that experimental condition positively related to T2 autonomous motivation. This supports the previous results, where the intervention seems to promote students' autonomous motivation throughout the intervention program. That means that the NSAI would help students to be autonomously motivated toward healthy behaviors, even during challenging times, and when they are far from the school environment. The NSAI helped students to autonomously pursue healthy behaviors because they were encouraged to make their PA purposefully and to do grouping activities, and they were encouraged to create activities to engage in PA behaviors by themselves. To do this, they needed to be responsible for their activities. Need satisfaction at T2 positively related to T3 autonomous motivation and cognitive function; whereas, T2 need frustration related positively to T3 controlled motivation and amotivation and related negatively to T3 cognitive function. These associations between variables on the bright side (i.e., need satisfaction with autonomous motivation) and on the dark side (i.e., need frustration with controlled motivation and amotivation) are consistent with previous studies (see Vasconcellos et al., 2020) and demonstrate that students with greater autonomy, competence, and relatedness generate more self-determined reasons toward PA. Furthermore, need satisfaction positively and need frustration negatively seem to determine cognitive functions at the end of the intervention.

Unlike with short interventions (e.g., Laporte et al., 2022), adolescents' autonomous behaviors to handle their activities might still depend on social contexts during long periods, and social contexts may need to directly (face to face) work with students to help them learn how to do their activities (i.e., a semester-long period). From an organismic approach, adolescents would proactively engage in activities to learn and get experience on how to satisfy their basic needs (Laporte et al., 2022); but, to do this, younger adolescents mostly depend on social contexts (e.g., teacher; Ryan & Deci, 2017). In other words, adolescents might handle their activities and feelings for short terms (Laporte et al., 2022), but they need more time to learn how to actively search the environment to satisfy their needs (Laporte et al., 2021) as well as to learn how to do their activities during long-term. It means that teachers' interpersonal behaviors would be an important resource to help students learn how to rely on inner motives and create activities for themselves (Laporte et al., 2022). Future research is recommended to measure students' self-support or need-crafting approach (Behzadnia & FatahModares, 2023; Laporte et al., 2022) toward their needs in such interventional research designs to investigate how the NSAI would affect their self-support approach and how that of self-support would affect their outcomes.

Finally, unexpectedly, T2 amotivation related positively to T3 PA behavior. While previous research has found that amotivation related negatively to PA in students (Owen et al., 2014), one correlational study found no relation between amotivation and PA in a sample of adults (Vazou & Vlachopoulos, 2014). The levels of PA across all three time points were lower than the recommendations (Craig et al., 2003). However, the control group values were low at T1, T2, and T3; hence, small oscillations in the means could have caused this positive relationship. Considering correlations, positive and significant relationships between the experimental group and PA levels were found at all three times ($r = .14$–$.17$). Furthermore, a negative relationship is observed between T1 amotivation and T1 PA, while there is no relationship between T1 amotivation and T2 and T3 PA, between T2 amotivation and T2

PA, nor T3 amotivation and T3 PA. Thus, amotivated students at T2 may come to do more PA at T3 due to the effect of the intervention—however, these need further research to understand how amotivation would be related to PA behaviors (e.g., a school year intervention design).

The current study has some limitations. First, some students have problems in terms of internet connection, and they may not have access to all online lessons, so it made it difficult for all students to follow and complete the programs over three waves, though we asked teachers to either provide the intervention for students more than twice a week or upload/record the programs along with their general PE syllabus in the Shad mobile application. Second, a convenience sample from secondary schools was used. Third, the small sample size and duration of the program might affect our findings. It is also important to note that problems with internet connection did not allow authors to follow students until the end of the school year. That is, the lack of a follow-up assessment does not allow us to examine the long-term effects of the intervention program. Future school-based randomized controlled trials with a longer duration would also more clearly show the effectiveness of the intervention. Fourth, data were exclusively collected from students' self-reported measures; it would be informative to collect data from other approaches, for example, collecting data through accelerators or mobile health application programs to specifically examine students' PA behaviors. In addition, future research is recommended to examine the performance of the activities by students. That is, although teachers provide examples for activities, the amount and duration of each activity might affect results. In other words, some students might spend more time on the activities but some might not, and these are important questions that need to be controlled in future research.

In this study, the intervention introduced the meaning and the importance of basic psychological needs to teachers and how their need-supportive behaviors would relate to students' positive outcomes and then the intervention followed by the NSAI. To help adolescents take responsibility for their basic needs, teachers might help students first experience a need-supportive climate and then ask them to do the activities. Social contexts play an important role in adolescents' reliance on inner resources (need-crafting) to create situations that enhance their need satisfaction (Laporte et al., 2021). However, future research would explore how adolescents create such situations for themselves in need-thwarting climates or amidst limitations. In addition, it would be informative, in future research, to examine the isolated effects of each intervention (teachers' need-supportive behaviors and students' NSAI). That is, previous research has shown that need-supportive interventions resulted in students' positive outcomes (e.g., Cheon et al., 2023), so it would be interesting to see how need-supportive intervention plus the NSAI would relate to students' positive outcomes compared with examining either need-supportive or the NSAI interventions separately in different groups (Celeux & Soromenho, 1996). To do this, future students focusing on NSAI might be structured such that the instructions about creating a need-supportive environment are reduced to a minimum. Moreover, in assessing the effect of prompting students to engage in the NSAI, it is important to distinguish between the teachers' provision of a need-supportive environment and the teachers' prompts to encourage students to autonomously engage in NSAI in future research, though it is difficult to create need-supportive activities without behaving in a need-supportive style.

In this study, teachers learned how to provide NSAI interventions in a need-supportive way as well as how to avoid need-thwarting behaviors. Need-supportive behaviors would be helpful for students' positive outcomes if teachers reduced their need-thwarting behaviors. That is, creating a need-supportive climate does not solely mean supporting students' psychological needs, it can be effective if teachers avoid need-thwarting behaviors—that is, research has shown that to see positive results of a need-supportive climate, it is important to avoid need-thwarting behaviors concurrently (Haerens et al., 2015; Leo, Mouratidis, et al., 2022; Vasconcellos et al., 2020). However, it is important to note that, since need-supportive activities are based on supporting needs (Ryan & Deci, 2017) and at no point are activities established that could frustrate needs, in this way we avoid generating thwarting activities. Moreover, in this study, we aimed to expand the literature on the effectiveness of somewhat similar online interventions in PE (e.g., Tilga, Kalajas-Tilga, Hein, & Koka, 2021) and to see how students benefit from online programs through a need-supportive activities program. Future research on how applying online need-supportive activities would help students' adaptive behaviors along with face-to-face need-supportive activities and how they supplement each other would be also interesting.

While in this study we, unexpectedly, did not find full support for our hypotheses, we expected to see similar positive outcomes with college students (Behzadnia & FatahModares, 2020). The main challenge for adolescents is how to learn to rely on inner resources to thrive and to manage their psychological needs during restrictions, and it seems that they struggled to take responsibility to self-manage their needs, though they received some support or instruction on how to do these (NSAI). From an organismic approach, it might be that adolescents have some authority issues to be able to rely on inner resources/abilities—that is, based on their family or social backgrounds, it might take time to learn how to manage their feelings and experiences of psychological needs (Ryan & Deci, 2017), which needs to be considered in future research.

In addition, in the hypothesized model, the NSAI did not relate to need satisfaction and frustration. One important stage to crafting needs or creating activities that help individuals satisfy psychological needs is to learn about the importance and value of psychological needs (De Bloom et al., 2020). That means when individuals learn about the nature or value of their psychological needs, it can result in higher need satisfaction (Behzadnia & FatahModares, 2023). Future research is thus recommended to either teach more about the value of needs or measure this result from the NSAI among adolescents. Also, the intervention time was relatively long, and it might look like it was sufficient to enhance students' need satisfaction, but perhaps to establish stable behavioral changes, it should carry out multicomponent interventions (Kelso et al., 2020).

The main conclusion of this research was that NSAI and teachers' need-supportive behaviors during online classes could be an opportunity to promote for students' autonomous motivation and cognitive function in PE. We extended previous research by conducting an online intervention program to motivate students toward healthy behaviors during the restrictions. Specifically, our paper demonstrates the importance of NSAI to students' motivational processes and cognitive function within the PE context.

Notes

1. Direct paths from experimental condition toward T2 autonomous motivation, and from T2 need satisfaction and T2 need frustration toward T3 cognitive function were added, as suggested by modification indices.

Acknowledgment

Ethical Approval: The procedure was approved by the University of Tabriz. The university research ethics committees approved the study protocol (ID: IR.TABRIZU.REC.1400.33). This research has been funded by the Iran National Science Foundation (INSF: 99029288).

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Appendix

Table A1 Demographic Characteristics of Participants

	Experimental condition ($N = 204$)	Control condition ($N = 291$)	Total ($N = 495$)
Age (years, $M \pm SD$, range)	15.80 ± 0.81, 15–17	15.36 ± 1.16, 13–17	15.54 ± 1.05, 13–17
SES ($M \pm SD$, range)	6.61 ± 2.78, 1–10	5.73 ± 2.24, 1–10	6.09 ± 2.52, 1–10
Gender (male, *n* [%])	161 (32.5%)	83 (16.8%)	244 (49.3%)
Grade (*N* [%])			
8–9	0 (0%)	42 (8.5%)	42 (8.5%)
10–12	204 (41.21%)	249 (50.29%)	453 (91.5%)

Note. SES = socioeconomic status.

Table A2 Descriptive Statistics, Internal Consistency, and Correlation Among Experimental Condition and the Study Variables

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1	Experimental condition	—																											
	Time 1																												
2	Need support	.05	*.92*																										
3	Need thwart	**.10**	**−.27**	*.79*																									
4	Need satisfaction	.08	**.36**	**−.19**	*.67*																								
5	Need frustration	.02	**−.23**	**.34**	**−.38**	*.61*																							
6	Autonomous M	**.14**	**.37**	**−.11**	**.52**	**−.24**	*.88*																						
7	Controlled M	**.19**	**.13**	**.27**	.01	**.22**	**.31**	*.78*																					
8	Amotivation	−.04	**−.24**	**.36**	**−.35**	**.36**	**−.45**	**.17**	*.81*																				
9	Cognitive function	−.02	**.21**	**−.38**	**.38**	**−.53**	**.28**	**−.24**	**−.43**	*.90*																			
10	Physical activity*	**.15**	−.03	.07	.06	.00	.04	**.12**	**−.10**	−.04	—																		
	Time 2																												
11	Need support	**.16**	**.47**	**−.21**	**.23**	**−.12**	**.30**	**.17**	**−.12**	**.18**	−.04	*.94*																	
12	Need thwart	.08	**−.24**	**.55**	**−.21**	**.27**	−.09	**.27**	**.30**	**−.30**	**.20**	**−.15**	*.83*																
13	Need satisfaction	**.22**	**.22**	−.09	**.47**	**−.23**	**.41**	**.12**	**−.23**	**.35**	.04	**.50**	−.08	*.73*															
14	Need frustration	−.03	**−.15**	**.26**	**−.27**	**.51**	**−.18**	**.16**	**.27**	**−.45**	.08	**−.18**	**.43**	**−.25**	*.73*														
15	Autonomous M	**.27**	**.15**	−.09	**.29**	**−.14**	**.59**	**.30**	**−.35**	**.23**	.12	**.47**	−.09	**.53**	**−.22**	*.92*													
16	Controlled M	**.19**	.07	**.27**	.07	**.19**	**.23**	**.64**	**.13**	**−.19**	.10	**.16**	**.35**	**.16**	**.31**	**.33**	*.83*												
17	Amotivation	−.06	**−.12**	**.27**	**−.19**	**.21**	**−.28**	.06	**.44**	**−.28**	.09	**−.25**	**.47**	**−.24**	**.43**	**−.39**	**.24**	*.88*											
18	Cognitive function	.03	**.17**	**−.32**	**.22**	**−.36**	**.17**	**−.18**	**−.31**	**.60**	−.03	**.25**	**−.44**	**.29**	**−.60**	**.31**	**−.30**	**−.53**	*.93*										
19	Physical activity*	**.17**	.03	.07	−.01	−.00	**.14**	**.26**	−.03	−.04	**.38**	.01	**.20**	.10	.03	**.15**	**.20**	.05	.00	—									
	Time 3																												
20	Need support	**.18**	**.50**	**−.13**	**.33**	**−.15**	**.32**	**.12**	**−.19**	**.26**	.03	**.64**	**−.25**	**.40**	**−.27**	**.32**	−.04	**−.28**	**.27**	−.07	*.95*								
21	Need thwart	.06	**−.26**	**.50**	**−.19**	**.25**	−.09	**.27**	**.34**	**−.36**	**.14**	−.08	**.61**	**−.03**	**.34**	.04	**.42**	**.25**	**−.40**	.08	**−.28**	*.85*							
22	Need satisfaction	**.20**	**.33**	**−.18**	**.49**	**−.22**	**.39**	.10	**−.28**	**.32**	−.02	**.40**	**−.23**	**.58**	**−.29**	**.39**	−.02	**−.26**	**.30**	.02	**.57**	**−.22**	*.78*						
23	Need frustration	.04	**−.24**	**.27**	**−.32**	**.38**	**−.13**	**.26**	**.31**	**−.44**	.08	**−.15**	**.47**	**−.26**	**.57**	**−.18**	**.37**	**.34**	**−.56**	−.00	**−.34**	**.53**	**−.36**	*.73*					
24	Autonomous M	**.32**	**.24**	−.10	**.35**	−.06	**.52**	**.28**	**−.28**	**.18**	**.14**	**.42**	−.11	**.47**	**−.15**	**.59**	.14	**−.29**	**.21**	.09	**.54**	−.12	**.64**	**−.18**	*.91*				
25	Controlled M	**.21**	.04	**.24**	−.01	**.20**	**.16**	**.56**	**.15**	**−.26**	**.20**	.08	**.26**	.09	**.39**	**.19**	**.72**	**.20**	**−.44**	.12	.10	**.38**	.08	**.39**	**.31**	*.85*			
26	Amotivation	−.10	**−.14**	**.28**	**−.22**	**.25**	**−.28**	.10	**.46**	**−.32**	−.05	**−.15**	**.33**	**−.15**	**.49**	**−.26**	**.38**	**.50**	**−.56**	−.03	**−.27**	**.41**	**−.29**	**.46**	**−.40**	**.36**	*.91*		
27	Cognitive function	.08	**.27**	**−.29**	**.37**	**−.37**	**.27**	**−.17**	**−.40**	**.68**	−.12	**.27**	**−.40**	**.43**	**−.50**	**.27**	**−.26**	**−.38**	**.70**	.01	**.36**	**−.51**	**.37**	**−.62**	**.34**	**−.34**	**−.58**	*.93*	

(continued)

Table A2 ***(continued)***

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
28	Physical activity	**.14**	−.02	**.20**	−.09	**.15**	.04	**.20**	.04	−.08	**.41**	−.08	**.33**	−.02	**.18**	.06	**.15**	**.25**	−.11	**.49**	−.04	**.17**	−.02	.07	.10	**.18**	.03	−.06	—
Experimental		*M*	5.65	2.85	4.10	2.13	3.42	1.65	0.55	3.89	238.2	5.79	2.85	4.14	2.12	3.41	1.73	0.60	3.79	232.4	5.72	2.87	4.17	2.10	3.37	1.69	0.68	3.86	254.1
		SD	0.96	0.98	0.59	0.61	0.57	0.83	0.74	0.57	223.5	0.99	1.03	0.58	0.68	0.67	0.92	0.92	0.70	201.2	1.07	1.15	0.58	0.71	0.62	0.99	0.96	0.64	196.8
Control		*M*	5.55	2.64	4.00	2.10	3.24	1.36	0.60	2.91	174.6	5.41	2.69	3.86	2.16	2.99	1.40	0.70	3.74	166.8	5.27	2.72	3.89	2.04	2.86	1.29	0.87	3.76	199.2
		SD	1.19	1.00	0.59	0.60	0.68	0.74	0.75	0.61	183.4	1.39	1.11	0.69	0.75	0.86	0.85	0.87	0.69	172.6	1.48	1.12	0.80	0.70	0.91	0.85	0.99	0.71	191.7

Note. Autonomous M = Autonomous motivation; Controlled M = controlled motivation. Bold values are significant. Values above .10 are significant at .05; values above .16 are significant at .01, and values above .20 are significant at .001. Italic values are Cronbach's alpha.