This is a self-archived version of an original article. This version may differ from the original in pagination and typographic details.

Author(s): Gråstén, Arto; Yli-Piipari, Sami; Huhtiniemi, Mikko; Salin, Kasper; Hakonen, Harto; Jaakkola, Timo

Title: A one-year follow-up of basic psychological need satisfactions in physical education and associated in-class and total physical activity

Year: 2021

Version: Accepted version (Final draft)

Copyright: © The Author(s) 2020

Rights: CC BY-NC-ND 4.0

Rights url: <https://creativecommons.org/licenses/by-nc-nd/4.0/>

Please cite the original version:

Gråstén, A., Yli-Piipari, S., Huhtiniemi, M., Salin, K., Hakonen, H., & Jaakkola, T. (2021). A one-year follow-up of basic psychological need satisfactions in physical education and associated in-class and total physical activity. *European Physical Education Review*, 27(3), 436-454.
<https://doi.org/10.1177/1356336X20957356>

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

**A one-year follow-up of basic psychological need satisfactions in physical education and
associated in-class and total physical activity**

Abstract

This study examined basic psychological need satisfactions for competence, autonomy, and social relatedness in physical education (PE) and their contributions to accelerometer-based in-class and total moderate to vigorous physical activity (MVPA) across a one-year follow-up. Participants were 523 students (girls 280, boys 243; $M_{age} = 11.26 \pm .31$) and the data were collected using self-reports and waist-worn accelerometers. The key findings were 1) competence and social relatedness need satisfaction at baseline (T0) predicted total MVPA at follow-up (T1) via total MVPA at T0, 2) in-class MVPA at T0 predicted total MVPA at T1 via total MVPA at T0, 3) in-class MVPA was directly associated with total MVPA at T0 and T1, and 4) boys scored higher than girls on competence and relatedness need satisfaction at T0. These findings indicate that the need satisfactions for competence and social relatedness in PE are central components facilitating the greatest increases in total MVPA participation. To improve student outcomes, it is essential that all children receive positive and satisfying PE experiences. Enhancing the readiness and capability of pre- and in-service teachers through teacher training programmes is vital to raising awareness of the basic psychological need satisfactions behind autonomous motivation and greater MVPA engagement.

Keywords

competence, autonomy, social relatedness, school, cross-lagged model

51 **Introduction**

52 Apart from many advantages, modern lifestyles have changed in less beneficial ways. For example,
53 only 30% of children meet the current guidelines of 60 minutes of daily moderate to vigorous
54 physical activity (MVPA), with boys being more physically active than girls (Tremblay et al.,
55 2016). MVPA is defined as all physical activities, such as brisk walking, running, or active games,
56 that increase the heart rate and cause rapid breathing (World Health Organization, 2018). It has
57 been proposed that physical education (PE) is the most important cost-effective way of increasing
58 regular MVPA at the population level, as it reaches the majority of school-aged children (Bassett et
59 al., 2013). However, achieving the objectives of PE, including life-long engagement in physical
60 activity, is challenging if children are not motivated to actively participate during their PE classes
61 (Ntoumanis, 2001). Despite the growing body of studies on MVPA-related motivation (De Meyer et
62 al., 2014; Haerens et al., 2013; 2015; Wang et al., 2016), understanding of the associations between
63 psychological need satisfactions, as posited in the Self-determination Theory (SDT; Deci and Ryan,
64 1985; 2000; Ryan and Deci, 2017), and accelerometer-based MVPA scores in PE over a prolonged
65 period, is lacking. This study examined these associations across one year in a sample of school-
66 aged children.

67 School PE is planned and progressive curricular learning, which is delivered to all students
68 and involves aspects of “learning to move” (becoming more physically competent) and “moving to
69 learn” (learning through movement) (Harris, 2015). One of the main objectives of school PE is to
70 provide students with an exposure that will build up their interest toward in-class and out-of-school
71 MVPA (Finnish National Agency for Education, 2014). In Finland, where this study took place,
72 schools, taking local conditions into account, design their own curricula within the framework of
73 the national curriculum. Typically, children in grades three to six receive 90 minutes of PE weekly
74 (Finnish National Agency for Education, 2014). In many schools, girls and boys are taught
75 separately in gender-specific PE groups. Based on previous studies, children’s MVPA during PE

classes depends on many factors, such as skill levels (Fairclough and Stratton, 2006), lesson themes (Slingerland, 2014), gender (Slingerland, 2014), the lesson venue (Mersh and Fairclough, 2010), resources available (Levin et al., 2001), teacher specialisation (Sallis et al., 1997), and class size (McKenzie et al., 2000). Since previous research has shown motivation to be an important determinant of in-class MVPA, increasing attention has been paid to the role of PE motivation in total MVPA (Ntoumanis and Standage, 2009; Vanttaja et al., 2017).

SDT (Deci and Ryan, 1985; 2000; Ryan and Deci, 2017) has been found advantageous as a theoretical framework for understanding behavioural processes in the PE context. According to SDT, the basis of motivational behaviour lies in the satisfaction of basic psychological needs for competence, autonomy, and social relatedness (Deci and Ryan, 1985; 2000; Ryan and Deci, 2017).

Need for competence refers to the need to be successful in an activity (Ryan and Deci, 2017).

Autonomy is the need to engage in activities for growth, volition, and willingness, and social relatedness the need to feel connected and interact with others. If school PE helps students to meet or satisfy these needs by increasing their perceptions of efficacy in given activities (competence), increasing their opportunities to develop interest or value in activities (autonomy), and supporting and encouraging their relationships with their teachers and peers (relatedness), students are likely to be more autonomously motivated (i.e. engage in activities for growth, stimulation, and enjoyment) to participate in PE. In the PE context, some studies have found that competence need satisfaction is the strongest predictor of higher autonomous motivation (Standage et al., 2005; Taylor et al., 2010).

Despite this, the current focus in the research literature is the combination of need satisfaction with need frustration (Chen et al., 2015; Ryan et al., 2016; Warburton et al., 2020), as they have been shown to co-occur with differential effects on the outcomes experienced by young people in learning settings such as school PE (De Meyer et al., 2014; Haerens et al., 2013; 2015; Sun et al., 2017; Wang et al., 2016). In line with the objectives of the Finnish national PE curriculum (Finnish National Agency for Education, 2014), the present study focused on need satisfactions over

frustrations, as the satisfactions may have protective effects even when need frustration is experienced (Warburton et al., 2020). Hence, to optimise autonomous motivation in PE, positive need satisfactions could be enhanced (De Meyer et al., 2014; Haerens et al., 2013; 2015; Sun et al., 2017; Wang et al., 2016). Empirical evidence supports this assumption as the need satisfaction for competence (Cox et al., 2008; Gråstén and Watt, 2017), autonomy (Chatzisarantis and Hagger, 2009; Lonsdale et al., 2009) and social relatedness (Gråstén and Watt, 2017; Taylor et al., 2010) have been shown to be associated with both total MVPA engagement and in-class MVPA. In addition, associations between in-class and total MVPA have been found in school-based PE studies (Dale et al., 2000; Gråstén et al., 2019).

With respect to gender, girls have been found to report less competence (Mouratidis et al., 2015; Ullrich-French and Cox, 2014) and autonomy need satisfaction (Mouratidis et al., 2015; Soini et al., 2007) but more relatedness need satisfaction in PE than boys (Gråstén and Watt, 2017). Some studies have found no gender differences in relatedness satisfaction among school students (Mouratidis et al., 2015; Xiang et al., 2017) or that boys reported higher relatedness need satisfaction than girls (Ntoumanis et al., 2009; Ullrich-French and Cox, 2014).

To summarise, the impact of SDT-based motivation in the PE context has been widely researched (De Meyer et al., 2014; Haerens et al., 2013; 2015; Wang et al., 2016). The most relevant application of SDT in PE pedagogy is that a teacher can motivate students to engage and learn in class through supporting need satisfactions (Chang et al., 2016). Intervention studies aimed at increasing students' self-determined motivation in PE are well-documented in the literature (Aelterman et al., 2014; Chatzisarantis and Hagger, 2009; Franco and Coterón, 2017). Of the three needs, most previous intervention studies have aimed at providing autonomy support in PE classes as a way of stimulating students' motivation (Chang et al., 2016). It has also been found that classroom experiences of autonomy and competence in PE are influenced more by teachers than peers, whereas relatedness is influenced by both peers and teachers (Vasconcellos et al., 2019).

Despite the large body of previous SDT-based studies on the topic of PE, several important issues remain unclear. For example, it is largely unknown how changes in all three basic psychological need satisfactions in school PE contribute to MVPA in PE and, more importantly, to total MVPA over time. A recent review by Vansteenkiste et al. (2020) and a need profile study by Warburton et al. (2020) concluded that more longitudinal work on need satisfactions over time is needed. Previous studies conducted among elementary school children (Ullrich-French and Cox, 2014), secondary school (Ntoumanis et al., 2009; Ratelle and Duchesne, 2014) and university students (Gillet et al., 2019) have revealed considerable heterogeneity in need satisfaction trajectories.

This follow-up study extends previous research on the topic by investigating the longitudinal relationships between the three psychological need satisfactions in PE and in-class and total MVPA. In addition to need satisfaction studies with adolescents (Ntoumanis et al., 2009; Ratelle and Duchesne, 2014), it would be also important to examine the longitudinal associations between need satisfactions and MVPA scores over time in elementary school children, as it is at this stage that the decline in physical activity usually begins (Slingerland, 2014; Telama et al., 2005; Tremblay et al., 2016). Since boys have been found to be more physically active (Tremblay et al., 2016; Yli-Piipari et al., 2012) and score higher on competence (Fairclough, 2003; Yli-Piipari et al., 2012) and autonomy needs (Mouratidis et al., 2015; Soini et al., 2007) than girls, and conflicting findings have been reported for social relatedness need satisfaction between girls and boys (Gråstén and Watt, 2017; Mouratidis et al., 2015; Ntoumanis et al., 2009; Ullrich-French and Cox, 2014; Xiang et al., 2017), gender differences were also examined over time. The present findings may be utilised to develop more effective PE teaching practices to fulfil basic need satisfactions, especially in younger children, as it is crucial that children have positive physical activity experiences in PE during their elementary school years (Jaakkola et al., 2019).

Mindful of these considerations, the specific aims of this study were 1) to examine the associations between the need satisfaction for competence, autonomy, social relatedness, in-class

MVPA, and total MVPA across a period of one year (Figure 1) and 2) to analyse gender differences in these associations, means, and variances over time. Based on the current literature review, higher satisfaction of the needs for competence, autonomy, and relatedness was expected to be positively linked with higher in-class MVPA and total MVPA at baseline and also at follow-up, although these associations have not been previously investigated in a follow-up design. Positive associations between in-class and total MVPA were also expected. Girls were expected to report higher social relatedness need satisfaction, while boys were believed to score higher on competence and autonomy need satisfaction.

[Figure 1 here]

Methods

Participants and procedure

Participants were 523 (girls 280, boys 243) Finnish grade five children aged 11 to 13 with a mean age of $11.26 \pm .31$ years at the beginning of the data collection. Children were recruited from 18 randomly selected public-sector schools in Southern (26% of students) and Central (74%) Finland. The sample distribution reflects the basic characteristics of Finnish schools (i.e. Finnish-speaking, middle-size schools with approx. 500 students per school with no rankings, comparisons or competition between students, schools or regions, and every school serving the same national goals and drawing from the same pool of university-trained teachers). Through direct contact with the schools' principals, all grade five students were invited to participate. Children represented 38 study groups taught by classroom teachers, who were the same at both T0 and T1. The total number of children completing the survey was 510 (T0) and 473 (T1) and with accelerometer data 415 (T0) and 274 (T1). All students participated in regular PE classes (two x 45 minutes of PE per week), no students with special needs participated in the study, although the opportunity was given to all

students equally. Class sizes varied between schools, students typically being taught PE in groups of 16 to 28 students. All teachers were specialised in elementary school education, but had been trained to teach PE as well. The content of all PE classes focused primarily on developing fundamental movement skills, i.e. running, jumping, and throwing in soccer and track and field activities (Finnish National Agency for Education, 2014).

The first measurement phase was conducted in August-September 2017 (T0) and the second during the same months in 2018 (T1). Both measurements were implemented using the same procedures. Students answered to the questionnaires in the schools' computer labs or classrooms under the supervision of teachers and researchers. Students were encouraged to answer honestly, and they were assured that their responses were confidential. Children were advised ask for help if needed and told that their participation was optional and that they could withdraw at any time without any consequences. To implement the objective MVPA measurements, researchers entered the students' demographic details and gave them instructions on how to use the activity monitors. Teachers collected the accelerometers and the researchers downloaded the data using the manufacturer's software (Actilife 3.6.0, ActiGraph). Participation was voluntary and was not rewarded with extra credits. Students who returned signed parental consents were permitted to participate in the study. Students who had a medical condition or physical injuries reported by parents before the commencement of the study were excluded. The ethical committee of the local university approved the study.

Measures

Demographic information was collected during PE classes in the same weeks as the MVPA measurements. Height (130 to 172 cm, $M = 148 \pm 7$ cm) and weight (26 to 76 kg, $M = 41.5 \pm 8.5$ kg) were measured. Body mass index (14 to 33, $M = 19 \pm 2.9$) was calculated (kg/m^2) using the cut-off points for 12 to 16 years old girls (22.14 to 24.54) and boys (21.56 to 24.19) presented by Cole

et al. (2000). Students were measured by the researcher in a separate space so that each student's information remained confidential and students did not see each other's results.

The Finnish version of the Basic Psychological Needs in Physical Education Scale (BPN-PE; Vlachopoulos et al., 2011) was used to assess the satisfaction of needs for competence, autonomy, and social relatedness in PE. The item stem was "*In PE classes I feel that...*" The scale consisted of 12 items divided among three subscales: competence (e.g. *I can do well even in the lessons considered difficult by most kids in my class*), relatedness (e.g. *my relationships with the other kids in my class are friendly*), and autonomy (e.g. *we do things in class that interest me*). All three subscales were measured on five-point response scales from (1) *totally disagree* to (5) *totally agree*. Gråstén et al. (2019) reported acceptable construct validity for the Finnish version ($\chi^2(50) = 106.59$, $p < .001$, $CFI = .97$, $TLI = .96$, $RMSEA = .048$, $SRMR = .035$) in a sample of Finnish elementary school students.

In-class and total MVPA (minutes per day) were measured using triaxial Actigraph GT3X+ accelerometers. Total MVPA was collected across a period of seven days, and in-class MVPA was extracted from total MVPA. During the measurement period, students participated in two PE classes (two x 45 minutes) following the local curriculum. The activity monitors were light, small, easy to use, and were worn on the right waist. The devices collected the data at 15-second intervals, as longer sampling intervals might have been inaccurate with young children (Nilsson et al., 2002). Only daytime activity (7am to 11pm), excluding water-based activities as the accelerometer model used was not waterproof, was included in the analyses. Following the protocol adopted in the earlier studies of Bergh et al. (2011) and Gråstén and Watt (2016), total MVPA minutes were considered valid if a child had at least three days, including one PE class and one weekend day, with at least 500 minutes of activity recorded per day. Periods of 30 minutes of consecutive zero counts were defined as non-wear time (Heil et al. 2012). The lower threshold for moderate-intensity activity was

2296 counts per minute (Evenson et al., 2008). The device used has previously been calibrated for young people in laboratory and free-living conditions (Martinez-Gomez et al., 2012).

Statistical analyses

Data were examined for normality of distributions, outliers (Tabachnick and Fidell, 2007) and missing values (Little and Rubin, 2002). Next, descriptive statistics, including correlations, means and standard deviations for the study variables, were determined. Since the data were expected to be hierarchical, intraclass correlation coefficients were calculated to detect variation in the study variables between classes and schools (Koo and Li, 2016). To examine the direct and indirect associations between the competence, autonomy, and relatedness need satisfactions, MVPA in PE, and total MVPA, a cross-lagged model using latent variables was estimated. A complex option with maximum likelihood estimation and robust standard errors was used to correct the possible non-independence of observations based on students being nested within their classes (Asparouhov, 2006). Gender differences in the loadings between paths from T0 and T1, means, and variances were tested using two-group tests based on Chi-square, in which two nested models can be examined by constraining the subsequent parameters to be equal (Muthén and Muthén, 2013). Equality of means between repeated measurements at T0 and T1 were tested using the Wald's test of parameter equality (Williams, 2015).

The Chi-square test (χ^2) was used as a test of the model's overall goodness-of-fit to the data. A non-significant difference between the observed and theoretical distribution demonstrated acceptable fit (Hu and Bentler, 1999). To examine the appropriateness of the model, the root mean square error of approximation (RMSEA), standardised root mean square residual (SRMR), comparative fit index (CFI), and Tucker-Lewis index (TLI) were examined (Hu and Bentler, 1999). A value of .08 or less for SRMR indicates the reasonable magnitude of a varying quantity, a value of .06 or less for the RMSEA indicates an acceptable model fit (Hu and Bentler, 1999). CFI and

TLI indices greater than .95 are indicative of an excellent model fit (Hair et al., 2010). The preliminary data analyses were performed using SPSS Version 22.0 and structural equation models using Mplus Version 8.2.

Results

Preliminary analysis

Data were normally distributed, and no significant outliers were detected based on the standardized values (± 3.00). The data matrix included 15.79% of missing values (826 out of 5230), owing to incomplete self-report or MVPA scores. The Missing Completely at Random (MCAR) test ($\chi^2(245) = 279.78, p = .063$) indicated that the data matrices with and without missing scores were similar. A closer examination of the data supported that missing values were missing completely at random, as the missing scores did not represent any particular school or group. Missing values were then estimated using the Full Information Maximum Likelihood Estimation method, which has been shown to produce unbiased parameter estimates and standard errors under MCAR conditions (Enders and Bandalos, 2001).

Descriptive statistics

The correlation coefficients, means, standard deviations, and Cronbach alphas for the study variables were examined (Table 1). The correlations between variables ranged from weak to strong. The strongest positive correlation was found between the autonomy and relatedness need satisfactions at T1. The mean difference tests between the T0 and T1 measurements revealed that autonomy need satisfaction, MVPA in PE and total MVPA declined in girls and that competence, autonomy, relatedness satisfactions and total MVPA declined in boys over time (Table 2). The proportions of children meeting the current MVPA guidelines varied over time (girls 38% at T0 and 29% at T1; boys 54% at T0 and 49% at T1), with total MVPA minutes per day ranging from 16 to

128 (T0) and 17 to 114 (T1) in girls and 11 to 129 (T0) and 19 to 119 (T1) in boys. The intraclass correlation coefficients showed no variation between classes or schools in competence, autonomy or total MVPA and low to moderate variations in relatedness at T1 and in-class MVPA at T0 and T1 (Table 3). Because MVPA in PE was indicated to have a multilevel structure, the following cross-lagged model was implemented using the complex model option to adjust for sampling weights (Asparouhov, 2006).

[Table 1 here]

[Table 2 here]

[Table 3 here]

Associations between basic psychological need satisfactions and MVPA

First, to examine the appropriateness of the theorised measurement model including needs for competence, autonomy, relatedness, MVPA in PE, and total MVPA at T0 and T1, both girls and boys were combined as a single group in the same model. The theorised model revealed an acceptable model fit ($\chi^2(329) = 666.54, p < .001, CFI = .93, TLI = .92, RMSEA = .044, 90\% CI [.04, .05], SRMR = .046$). The model showed significant direct and indirect paths between the study variables (Figure 2). Squared multiple correlations (R^2) showed that the model explained 19% to 35% of the variability of total MVPA and 9% of the variability of in-class MVPA, excluding the non-significant squared multiple correlation of in-class MVPA at T0.

[Figure 2 here]

Gender differences in need satisfactions and MVPA

To test for gender differences between the loadings from T0 to T1, a series of two-group tests was implemented by fixing the loadings between T0 and T1 to be equal. Significant gender differences emerged in the loadings between social relatedness satisfaction at T0 and T1 ($\chi^2(1) = 4.45, p < .05$) and social relatedness satisfaction at T1 and total MVPA at T1 ($\chi^2(1) = 4.29, p < .05$), specifically between relatedness T0 and relatedness T1 (girls = .52, boys = .60) as well as relatedness T1 and total MVPA T1 (girls = -.05; boys = .18). To test the equality of means and variances to identify significant differences between girls and boys, a series of two-group tests was implemented. The results showed that boys scored higher than girls on competence at T0 ($\chi^2(1) = 14.86, p < .001$) and relatedness need satisfaction at T0 ($\chi^2(1) = 5.59, p < .05$) and that gender differences existed in the variances of social relatedness satisfaction at T0 ($\chi^2(1) = 5.60, p < .05$) and in-class MVPA at T1 ($\chi^2(1) = 12.74, p < .001$).

Discussion

This study investigated the associations between the satisfaction of basic psychological needs for competence, autonomy, and social relatedness, MVPA in PE, and total MVPA. The study also examined gender differences over time. Based on the current SDT literature in the area, higher satisfaction of the needs for competence, autonomy, and relatedness was expected to be linked with higher in-class MVPA, and total MVPA at baseline. Although a few previous studies in the SDT literature have presented need satisfaction trajectories over time (Ntoumanis et al., 2009; Ratelle and Duchesne, 2014; Ullrich-French and Cox, 2014), no studies investigating need satisfactions over time have concurrently examined competence, autonomy, and relatedness in the domain of physical activity. Thus, this study contributes to the literature on the topic by examining how changes in all three basic psychological need satisfactions in PE contribute to MVPA in PE and to total MVPA over time. As expected, the positive paths from competence need satisfaction, social relatedness need satisfaction, and in-class MVPA to total MVPA as well as gender differences in

324 competence and relatedness, favouring boys were evident. It was unexpected that the association
325 between autonomy need satisfaction and total MVPA at T0 was negative.

326 First, the results showed that the need satisfaction for competence in PE predicted later total
327 MVPA at T1 via total MVPA at T0, thereby corroborating previous findings (Cox et al., 2008;
328 Gråstén and Watt, 2017; Gråstén et al., 2019). In the context of the present Finnish PE curriculum
329 (Finnish National Agency for Education, 2014), the importance of competence need satisfaction
330 when examining engagement in MVPA is understandable. This assumption is one of the most
331 important cornerstones of the Finnish PE curriculum and as the present results show, manifests a
332 positive longitudinal relationship between competence and MVPA engagement. Hence, to enhance
333 children's total MVPA engagement, it is essential that they are provided with competence
334 supportive activities in PE classes. This is especially important for girls, who are typically less
335 physically active than boys (Tremblay et al., 2016; Yli-Piipari et al., 2012). Following the
336 suggestions of previous SDT-based PE programmes, the need for competence, especially among
337 girls, could be supported by emphasizing effort and arranging activities in which students can
338 experience optimal challenge (Standage and Ryan, 2012) and also more positive feedback (Doolittle
339 and Rukavina, 2014; Standage and Ryan, 2012). For example, students could be instructed in how
340 to give each other appropriate feedback from a very early age, such as through simple hand gestures
341 or by holding up printed cards. As during the school career, students' ability to give feedback
342 develops, they could use more versatile means of communication. Students could also be given
343 more opportunities to comment and express respect for their experiences, thereby promoting deeper
344 understanding and learning (Culp, 2013). For example, when teachers developed a coordinated
345 school physical activity program for middle school students, they offered volleyball and table tennis
346 classes because of the strong interest shown by students (Doolittle and Rukavina, 2014). As
347 described above, competence need satisfactions could be supported in numerous different ways to
348 lift student outcomes. Although optimal functioning driven by competence need satisfaction is

likely to be similar across cultures (Chen et al., 2015), strategies introduced to support competence satisfaction in PE classes may best work in Finnish or other less authoritarian school systems. In the Finnish school system, relationships between teachers and students tends towards informality, meaning that students find it easy to approach their teachers (Kauppi and Pörhölä, 2012). In school cultures with more formal teacher-student relationships, such methods may need some modification. As supporting competence need satisfaction in PE classes appears to be important in ensuring positive MVPA engagement over time, it would be crucial to identify students, whose level of competence satisfaction is low. This may be even more valuable than viewing the transition over time itself as a risk for poor student outcomes (Ullrich-French and Cox, 2014).

Second, in line with previously established associations (Gråstén and Watt, 2017; Taylor et al., 2010) social relatedness satisfaction at baseline was related with total MVPA at follow-up via baseline MVPA. Children who reported positive relatedness need satisfaction when engaged in PE activities were generally more physically active. This finding underlines the importance of the social aspects of PE lessons for total MVPA engagement. To support social relatedness need satisfaction across PE lessons, students could be given opportunities in their learning teams to develop their content knowledge and refine their performance through peer teaching instructional tasks (Standage and Ryan, 2012; Wallhead et al., 2013). Furthermore, students could be provided with a well-structured environment that gives clear guidelines (open teacher-student communication) and opportunities for social learning (cooperation between students), provides optimal challenges, and offers detailed feedback on how to achieve desired outcomes (Taylor and Ntoumanis, 2007). Given that some previous studies have revealed direct associations between larger class sizes and higher levels of antisocial behaviour (Reeves, 2010), class sizes should be judiciously considered, when grouping PE students. If classes are too large, the PE teacher does not have enough time to give detailed student feedback as a way of optimising learning outcomes. All such improvements rely on good cooperative working arrangements between teachers, students, and

374 other school personnel, including school principals, who play important roles in supporting clear
375 and consistent communication via the creation of a positive school climate (Smith et al., 2014).
376 From perspective of PE teachers, attempts to implement respectful cooperation between schools and
377 families could support social relatedness need satisfaction and the positive development of the
378 student-student as well as teacher-student relationship (Aldrup et al., 2018). Students in turn could
379 make a conscious effort to be positive role models for others and demonstrate good sportsmanship
380 within the boundaries set in cooperation by teachers and students (Smith et al., 2014).

381 An opposite and unexpected finding to the previous results in the field (Chatzisarantis and
382 Hagger, 2009; Lonsdale et al., 2009) was the negative relationship between autonomy and total
383 MVPA. In other words, students with higher total MVPA scores reported lower autonomy
384 satisfaction in PE classes. Based on the current data, it is difficult to draw clear reasons behind this
385 negative association. One possible explanation may be that PE lessons during the measurement
386 period did not support students' autonomy need satisfaction, although students were physically
387 active outside PE lessons, for instance when participating in leisure sports. This could be the case,
388 for instance, when students are provided with activities that they dislike or find less interesting
389 (Doolittle and Rukavina, 2014). It is possible that the lesson themes (Slingerland, 2014) or
390 resources available (Levin et al., 2001) during the measurement period did not support the need for
391 autonomy, leading students to report low autonomy scores. It should be mentioned that Finnish
392 school PE is not an elective subject but compulsory for all grade 1 to 9 students. Hence, it cannot be
393 assumed that students' autonomy need satisfaction is fully met in all PE lessons. The associations
394 could have been positive if the measurement period had covered several PE lessons. For example,
395 Chatzisarantis and Hagger (2009) collected PE data during a 5-week intervention. Reeve (2009)
396 suggests several strategies to facilitate positive autonomy need satisfaction in PE classes. For
397 instance, teachers could provide explanatory rationales (articulate the sometimes unmentioned use
398 underlying a teacher's request), rely on non-controlling language (informational communication

often helps students to diagnose and solve their motivational problems), display patience by allowing students the time they need for self-paced learning to occur (give students time to work in their own way), and acknowledge and accept students' expressions of negative affect (treat students' complaints as valid reactions to imposed demands and structures). Although it is difficult to explain the current negative association, it might, based on previous research findings, be fruitful to promote autonomy in curriculum-based activities in PE classes. If successful, this is likely to translate into higher total MVPA scores, which is needed across the life-span (Tremblay et al., 2016).

The results also showed the importance of MVPA in PE classes and its contribution to total MVPA engagement. As expected, baseline MVPA in PE classes predicted total MVPA at follow-up. Specifically, in-class MVPA accounted, on average, for 37% of total MVPA in all students over the study period. This result supports previous Finnish (Gråstén et al., 2015; 2019) and international (Bailey et al., 2012) findings. The present total MVPA scores indicated that children's MVPA levels were insufficient, which is a matter of great concern. Many potential strategies can be deployed to increase the amount of MVPA time in PE classes. Schools could, for instance, review class sizes, reduce time spent in locker rooms, and implement instant activities instead of sitting and waiting for instructions at the beginning and end of the class (McKenzie et al. 2000), establish routines for the more efficient supply of equipment by letting students assist with the care and proper storage of PE teaching materials (Gråstén et al., 2017), integrate objective devices into PE classes to monitor MVPA behaviour (Strand and Reeder, 2013), and reassess MVPA time and use the results to refine and improve practice (Freedson et al., 2012; McKenzie et al. 2000). It is clear that students need more MVPA than schools alone can provide. Hence, ensuring that they have satisfying and positive PE experiences may facilitate the adoption of a more active lifestyle outside of PE.

Finally, in line with previous studies (Mouratidis et al., 2015; Ullrich-French and Cox, 2014), boys had higher baseline competence need satisfaction. Contrary to some previous evidence, boys also had higher baseline social relatedness need satisfaction than girls. Compared to an earlier Finnish study reporting opposite results (Gråstén and Watt, 2017), it is possible that the boys in the present sample experienced more opportunities to interact with peers in out-of-school activities. If so, they may also manifest as higher social relatedness satisfaction scores in PE classes. However, Howie et al. (2010) reported that children who participated more frequently in sports had higher social skill scores than those who participated less frequently in sports. This may also explain the differences between groups in the current study. Many previous studies have reported that interaction with peers plays a critical role in the development of children's social competence (Branchi et al., 2013; Gifford-Smith and Brownell, 2003) which, although not the same, is closely associated with SDT-based social relatedness. It is also important to remember that physical appearance, physical development, and bodily changes in early adolescent girls appear to be associated with negative perceptions of social relatedness (Craft et al., 2003). If so, this may be reflected in the present lower scores in girls. It has been suggested that perceptions of social relatedness among adolescent girls may be enhanced by emphasizing friendship and social interaction in PE classes and minimising social comparisons (Craft et al., 2003). According to Gibbons (2014), a socially supportive learning environment in PE could be created by including cooperative games and team-building activities, helping students to develop connections with teachers and peers (learn the names of your students, use icebreakers), using group rotation (by the end of the semester everyone has worked with everyone else), reinforcing positive behaviour, avoiding stereotypical language ("girls' push-ups"), asking students how to create a safer environment, and implementing a respectful process of choosing teammates (you must accept the first person who responds, if someone does not have a group invite them into your group). Thus, there are many practical ways of enhancing social interaction in PE lessons.

448

449 *Limitations and future research directions*

450 The strengths of the present study were the relatively large and nationally representative sample
451 size, follow-up design, and the use of objective MVPA measures. The study nevertheless has its
452 limitations. First, self-reported need satisfactions for competence, autonomy, and relatedness may
453 vary in accuracy more than objective measurement protocols, such as observation tools. Second,
454 school-based “real-life” follow-up studies are always vulnerable in that it is not possible to control
455 for all the factors underlying physical activity behaviour. Finally, this study focused on need
456 satisfactions that accorded with the objectives of the national PE curriculum, and thus need
457 frustrations were not included in the measurements. Future studies could investigate teaching
458 strategies that could help standardise practices in PE that support autonomy, competence, and
459 relatedness. As this study focused on student-student relationships in respect of social relatedness
460 need satisfaction, it would also be interesting to look more closely at student-teacher interactions. In
461 addition, the associations between psychological need satisfactions, frustrations, and actual MVPA
462 behaviour could be examined using follow-up designs with children and adolescents at different
463 ages.

464

465 **Conclusion**

466 The present results showed the importance of in-class MVPA and its contribution to total MVPA
467 engagement. To increase the amount of daily MVPA time, it would seem to be crucial to support
468 the need satisfactions for competence and social relatedness in PE classes. This is especially
469 important among girls, as they normally accrue fewer daily MVPA minutes than boys. An increased
470 use of need-centred teaching strategies could promote student engagement in the PE context.
471 Children could also be more heavily involved in the planning process and implementation of their

PE lessons. Such actions could enhance children's sense of autonomy, competence, social relatedness, in-class MVPA and, most importantly, total MVPA engagement over the long term. Concerns arising from these findings were that total MVPA declined over time in both girls and boys, and a smaller proportion of children met the current MVPA guidelines at follow-up. Schools alone cannot provide all the MVPA children need. To help children achieve a physically active lifestyle later in their lives, it is essential to ensure that all students enjoy positive and satisfying PE experiences. To raise awareness of the basic psychological need satisfactions and improve student outcomes, it would be vital, through teacher training programmes, to enhance the readiness and capability of pre-service teachers, as they will play a crucial role in stimulating autonomous motivation and greater MVPA engagement.

Acknowledgements

Authors want to thank Professor Richard Ryan (Institute for Positive Psychology and Education, Australian Catholic University) for pre-reviewing the first version of this manuscript.

Declaration of conflicting interests

The authors declare no potential conflicts of interests with respect to the research, authorship, and/or publication of this article.

Funding

This study was financially supported by the Finnish Ministry of Education and Culture and the Otto A. Malm Foundation, Finland.

References

- Aelterman N, Vansteenkiste M, Van den Berghe L, De Meyer J and Haerens L (2014) Fostering a need-supportive teaching style: Intervention effects on physical education teachers' beliefs and teaching behaviors. *Journal of Sport and Exercise Psychology* 36(6): 595–609.
- Aldrup K, Klusmann U, Lüdtke O, Göllner R and Trautwein U (2018) Student misbehavior and teacher well-being: testing the mediating role of the teacher-student relationship. *Learning and Instruction* 58: 126–136.
- Asparouhov T (2006) Sampling weights in latent variable modeling. *Structural Equation Modeling* 12(3): 411–434.
- Bailey D, Faircloud S, Savory L, Denton S, Pang D, Deane C and Kerr C (2012) Accelerometry-assessed sedentary behaviour and physical activity levels during the segmented school day in 10–14-year-old children: the HAPPY study. *European Journal of Pediatrics* 171(12): 1805–1813.
- Bassett D, Fitzhugh E, Heath G, Erwin P, Frederick G, Wolff D, Welch A and Stout A (2013) Estimated energy expenditures for school-based policies and active living. *American Journal of Preventive Medicine* 44(2): 108–113.
- Bergh H, Grydeland M, Bjelland M, Lien N, Andersen L, Klepp K, Anderssen S and Ommundsen Y (2011) Personal and social environmental correlates of objectively measured physical activity in Norwegian pre-adolescent children. *Scandinavian Journal of Medicine and Science in Sports* 21(6): 315–324.
- Branchi I, Curley J, D'Andrea I, Cirulli F, Champagne F and Alleva E (2013) Early interactions with mother and peers independently build adult social skills and shape BDNF and oxytocin receptor brain levels. *Psychoneuroendocrinology* 38(4): 522–532.

- 520 Chang Y, Chen S, Tu, K and Chi L (2016) Effect of autonomy support on self-determined
521 motivation in elementary physical education. *Journal of Sports Science and Medicine* 15(3):
522 460–466.
- 523 Chatzisarantis N and Hagger M (2009) Effects of an intervention based on self-determination
524 theory on self-reported leisure-time physical activity participation. *Psychology and Health*
525 24(1): 29–48.
- 526 Chen B, Vansteenkiste M, Beyers W, Boone L, Deci E, Van der Kaap-Deeder J, Duriez B, Lens W,
527 Matos L, Mouratidis A, Ryan R, Sheldon K, Soenens B, Van Petegem S and Verstuyf, J
528 (2015) Basic psychological need satisfaction, need frustration, and need strength across four
529 cultures. *Motivation and Emotion* 39(2): 216–236.
- 530 Cole T, Bellizzi M, Flegal K and Dietz W (2000) Establishing a standard definition for child
531 overweight and obesity worldwide: International survey. *BMJ Clinical Research* 320: 1240–
532 1243.
- 533 Cox A, Smith A and Williams L (2008) Change in physical education motivation and physical
534 activity behavior during middle school. *The Journal of Adolescent Health* 43(5): 506–513.
- 535 Craft L, Pfeiffer K and Pivarnik J (2003) Predictors of physical competence in adolescent girls.
536 *Journal of Youth and Adolescence* 32(6): 431–438.
- 537 Culp B (2013) Eliminating barriers to physical activity: Using cultural negotiation and competence.
538 *Strategies: A Journal for Physical and Sport Educators* 26(3): 35–40.
- 539 Dale D, Corbin C and Dale K (2000) Restricting opportunities to be active during school time: do
540 children compensate by increasing physical activity levels after school? *Research Quarterly*
541 *for Exercise and Sport* 71(3): 240–248.
- 542 De Meyer J, Tallir I, Soenens B, Vansteenkiste M, Aelterman N, Van den Berghe L, Speleers L and
543 Haerens L (2014) Does observed controlling teaching behavior relate to students' motivation
544 in physical education? *Journal of Educational Psychology* 106(2): 541–554.

- 545 Deci E and Ryan R (1985) *Intrinsic Motivation and Self-determination in Human Behaviour*. New
546 York: Plenum Press.
- 547 Deci E and Ryan R (2000) The "what" and "why" of goal pursuits: Human needs and the self-
548 determination of behavior. *Psychological Inquiry* 11(4): 227–268.
- 549 Doolittle S and Rukavina P (2014) Case study of an institutionalized urban comprehensive school
550 physical activity program. *Journal of Teaching in Physical Education* 33(4): 528–557.
- 551 Enders C and Bandalos D (2001) The relative performance of Full Information Maximum
552 Likelihood Estimation for missing data in structural equation models. *Structural Equation*
553 *Modeling* 8(3): 430–457.
- 554 Evenson K, Catellier D, Gill K, Ondrak K and McMurray R (2008) Calibration of two objective
555 measures of physical activity for children. *Journal of Sports Sciences* 26(14): 1557–1565.
- 556 Fairclough S (2003) Physical activity, perceived competence and enjoyment during secondary
557 school physical education. *The European Journal of Physical Education* 8(1): 5–18.
- 558 Fairclough S and Stratton G (2006) A Review of physical activity levels during elementary school
559 physical education. *Journal of Teaching in Physical Education* 25(2): 239–257.
- 560 Finnish National Agency for Education (2014) *National Core Curriculum for Basic Education*.
561 Helsinki: Finnish National Agency for Education.
- 562 Freedson P, Bowles H, Troiano R and Haskell W (2012) Assessment of physical activity using
563 wearable monitors: recommendations for monitor calibration and use in the field. *Medicine and*
564 *Science in Sports and Exercise* 4(1): 1–4.
- 565 Franco E and Coterón J (2017) The effects of a physical education intervention to support the
566 satisfaction of basic psychological needs on the motivation and intentions to be physically
567 active. *Journal of Human Kinetics* 59: 5–15.
- 568 Gibbons S (2014) Relatedness-supportive learning environment for girls in physical education.
569 *Learning Landscapes* 7(2): 139–150.

- 570 Gifford-Smith M and Brownell C (2003) Childhood peer relationships: Social acceptance,
571 friendships, and peer networks. *Journal of School Psychology* 41(4): 235–284.
- 572 Gillet N, Morin A, Huyghebaert T, Burger L, Mailliot A, Poulin A and Tricard E. (2019). University
573 students' need satisfaction trajectories: A growth mixture analysis. *Learning and Instruction*
574 60: 275–285.
- 575 Gråstén A and Watt A (2016) A comparison of self-report scales and accelerometer-determined
576 moderate to vigorous physical activity scores of Finnish school students. *Measurement in*
577 *Physical Education and Exercise Science* 20(4): 220–229.
- 578 Gråstén A and Watt A (2017) A motivational model of physical education and links to enjoyment,
579 knowledge, performance, total physical activity and body mass index. *Journal of Sports*
580 *Science and Medicine* 16(3): 318–327.
- 581 Gråstén A, Watt A, Hagger M, Jaakkola T and Liukkonen J (2015) Secondary school students'
582 physical activity participation in physical education classes – The expectancy-value theory
583 approach. *The Physical Educator* 72(2): 340–358.
- 584 Gråstén A, Watt A, Liukkonen J and Jaakkola T (2017) Effects of school-based physical activity
585 program on students' moderate to vigorous physical activity and perceptions of physical
586 competence. *Journal of Physical Activity and Health* 14(6): 455–464.
- 587 Gråstén A, Yli-Piipari S, Huhtiniemi M, Salin K, Seppälä S, Lahti J, Hakonen H and Jaakkola T
588 (2019) Predicting accelerometer-based physical activity in physical education and total
589 physical activity – The Self-determination Theory approach. *Journal of Human Sport and*
590 *Exercise* 14(4): 757–771.
- 591 Haerens L, Aelterman N, Van den Berghe L, De Meyer J, Soenens B and Vansteenkiste M (2013)
592 Observing physical education teachers' need-supportive interactions in classroom settings.
593 *Journal of Sport and Exercise Psychology* 35(1): 3–17.

- 594 Haerens L, Aelterman N, Vansteenkiste M, Soenens B and Van Petegem S (2015) Do perceived
595 autonomy-supportive and controlling teaching relate to physical education students'
596 motivational experiences through unique pathways? Distinguishing between the bright and
597 dark side of motivation. *Psychology of Sport and Exercise* 16(3): 26–36.
- 598 Hair J, Black W, Babin B and Anderson R (2010) *Multivariate Data Analysis*. Upper Saddle River,
599 NJ: Prentice-Hall Inc.
- 600 Harris J (2015) *Association for Physical Education Health Position Paper*. Loughborough
601 University: Association for Physical Education.
- 602 Heil D, Brage S and Rothney M (2012) Modeling physical activity outcomes from wearable
603 monitors. *Medicine and Science in Sports and Exercise* 44(1): 50–60.
- 604 Howie L, Lukacs S, Pastor P, Reuben C and Mendola P (2010) Participation in activities outside of
605 school hours in relation to problem behavior and social skills in middle childhood. *Journal of*
606 *School Health* 80(3): 119–125.
- 607 Hu L and Bentler P (1999) Cutoff criteria for fit indexes in covariance structure analysis:
608 Conventional criteria versus new alternatives. *Structural Equation Modeling* 6(1): 1–55.
- 609 Jaakkola T, Yli-Piipari S, Huhtiniemi M, Salin K, Seppälä S, Hakonen H and Gråstén A (2019)
610 Longitudinal associations among cardiorespiratory and muscular fitness, motor competence
611 and objectively measured physical activity. *Journal of Science and Medicine in Sport* 22(11):
612 1243–1248.
- 613 Kauppi T and Pörhölä M (2012) School teachers bullied by their students: Teachers' attributions
614 and how they share their experiences. *Teaching and Teacher Education* 28(7): 1059–1068.
- 615 Koo T and Li M (2016) A guideline of selecting and reporting intraclass correlation coefficients for
616 reliability research. *Journal of Chiropractic Medicine* 15(2): 155–163.

- 617 Levin S, McKenzie T, Hussey J, Kelder S and Lytle L (2001) Variability of physical activity during
618 physical education lessons across elementary school grades. *Measurement in Physical*
619 *Education and Exercise Science* 5(4): 207–218.
- 620 Little R and Rubin D (2002) *Statistical Analysis with Missing Data*. New York, NY: Wiley.
- 621 Lonsdale C, Sabiston C, Raedeke T, Ha A and Sum R (2009) Self-determined motivation and
622 students' physical activity during structured physical education classes and free choice
623 periods. *Preventive Medicine* 48(1): 69–73.
- 624 Martinez-Gomez D, Gomez-Martinez S, Ruiz J, Diaz L, Ortega F, Widhalm K, Cuenca-Garcia M,
625 Manios Y, De Vriendt T, Molnar D, Huybrechts I, Breidenassel C, Gottrand F, Plada M,
626 Moreno S, Ferrari M, Moreno LA, Sjöström M and Marcos A (2012) Objectively-measured
627 and self-reported physical activity and fitness in relation to inflammatory markers in
628 European adolescents: The HELENA Study. *Atherosclerosis* 221(1): 260–267.
- 629 McKenzie T, Marshall S, Sallis J and Conway T (2000) Student activity levels, lesson context, and
630 teacher behavior during middle school physical education. *Research Quarterly for Exercise*
631 *and Sport* 71(3): 249–259.
- 632 Mersh R and Fairclough S (2010) Physical activity, lesson context and teacher behaviours within
633 the revised English National Curriculum for Physical Education: A case study of one school.
634 *European Physical Education Review* 16(1): 29–45.
- 635 Mouratidis A, Barkoukis V and Tsorbatzoudis (2015) The relation between balanced need
636 satisfaction and adolescents' motivation in physical education. *European Physical Education*
637 *Review* 21(4): 421–431.
- 638 Muthén L and Muthén B (2013) *Mplus User's Guide*. Los Angeles, CA: Muthén and Muthén.
- 639 Nilsson A, Ekelund U, Yngve A and Sjostrom M. (2002) Assessing physical activity among
640 children using different time sampling intervals and placements. *Pediatric Exercise Science*
641 14(1): 87–96.

- 642 Ntoumanis N (2001) A self-determination approach to the understanding of motivation in physical
643 education. *British Journal of Educational Psychology* 71(2): 225–242.
- 644 Ntoumanis N, Barkoukis V and Thøgersen-Ntoumani C (2009) Developmental trajectories of
645 motivation in physical education: Course, demographic differences, and antecedents. *Journal*
646 *of Educational Psychology* 101(3): 717–728.
- 647 Ntoumanis N and Standage M (2009) Motivation in physical education classes: A self-
648 determination theory perspective. *Theory and Research in Education* 7(2): 194–202.
- 649 Ratelle C and Duchesne S (2014) Trajectories of psychological need satisfaction from early to late
650 adolescence as a predictor of adjustment in school. *Contemporary Educational Psychology*
651 39(4): 388–400.
- 652 Reeve J (2009) Why teachers adopt a controlling motivating style toward students and how they can
653 become more autonomy supportive. *Educational Psychologist* 44(3): 159–175.
- 654 Reeves M (2010) *Comprehensive Planning for Safe Learning Environments: A school*
655 *Professional's Guide to Integrating Physical and Psychological Safety*. New York, NY:
656 Routledge.
- 657 Ryan R and Deci E (2017) *Self-Determination Theory. Basic Psychological Needs in Motivation,*
658 *Development, and Wellness*. New York, NY: The Guilford Press.
- 659 Ryan R, Deci E and Vansteenkiste M (2016) Autonomy and autonomy disturbances in self-
660 development and psychopathology: Research on motivation, attachment, and clinical process.
661 In D Cicchetti (Ed.) *Developmental Psychopathology* (pp. 385-438). New York: Wiley.
- 662 Sallis J, McKenzie T, Alcaraz J, Kolody B, Faucette N and Hovell M (1997) The effects of a 2-year
663 physical education program (SPARK) on physical activity and fitness in elementary school
664 students. *American Journal of Public Health* 87(8): 1328–1334.
- 665 Slingerland M (2014) *Physical Education's Contribution to Levels of Physical Activity in Children*
666 *and Adolescents*. PhD Thesis, Maastricht University Maastricht, The Netherlands.

- 667 Smith T, Connolly F and Pryseski C (2014) *Positive School Climate: What It Looks Like and How*
668 *It Happens. Nurturing Positive School Climate for Student Learning and Professional*
669 *Growth*. Baltimore, MD: Baltimore Education Research Consortium.
- 670 Soini M, Liukkonen J, Jaakkola T, Leskinen E and Rantanen P (2007) Motivaatioilmasto ja
671 viihtyminen koululiikunnassa (in Finnish). *Liikunta ja Tiede* 44(1): 45–51.
- 672 Standage M, Duda J and Ntoumanis N (2005) A test of self-determination theory in school physical
673 education. *British Journal of Educational Psychology* 75(3): 411–433.
- 674 Standage M and Ryan R (2012) Self-determination theory and exercise motivation: Facilitating self-
675 regulatory processes to support and maintain health and well-being. In G Roberts and D
676 Treasure (Eds.) *Advances in Motivation in Sport and Exercise* (pp. 233–270) Champaign, IL:
677 Human Kinetics.
- 678 Strand B and Reeder S (2013) PE with a heartbeat—Hi-tech physical education. *Journal of Physical*
679 *Education, Recreation, and Dance* 64(3): 81–84.
- 680 Sun H, Li W and Shen B (2017) Learning in physical education: A self-determination theory
681 perspective. *Journal of Teaching in Physical Education* 36(3): 277–291.
- 682 Tabachnick B and Fidell L (2007) *Using Multivariate Statistics*. Boston: Allyn and Bacon.
- 683 Taylor I and Ntoumanis N (2007) Teacher motivational strategies and student self-determination in
684 physical education. *Journal of Educational Psychology* 99(4): 747–760.
- 685 Taylor I, Ntoumanis N, Standage M and Spray C (2010) Motivational predictors of physical
686 education students' effort, exercise intentions, and leisure-time physical activity: A multilevel
687 linear growth analysis. *Journal of Sport and Exercise Psychology* 32(1): 99–120.
- 688 Telama R, Yang X, Viikari J, Välimäki I, Wanne O and Raitakari O (2005) Physical activity from
689 childhood and adulthood: a 21-year tracking study. *American Journal of Preventive Medicine*
690 28(3): 267–273.

- 691 Tremblay M, Barnes J, González S, Katzmarzyk P, Onywera V, Reilly J, Tomkinson G, and Global
692 Matrix 2.0 Research Team (2016) Global Matrix 2.0: Report card grades on the physical
693 activity of children and youth comparing 38 countries. *Journal of Physical Activity and*
694 *Health* 13(2): 343–366.
- 695 Ullrich-French S and Cox A (2014) Normative and intraindividual changes in physical education
696 motivation across the transition to middle school: A multilevel growth analysis. *Sport,*
697 *Exercise, and Performance Psychology* 3(2): 132–147.
- 698 Vansteenkiste M, Ryan R and Soenens B (2020) Basic psychological need theory: Advancements,
699 critical themes, and future directions. *Motivation and Emotion* 44(1): 1–321.
- 700 Vanttaja M, Tähtinen J, Zacheus T and Koski P (2017) *Tracking of Inactivity: Longitudinal Study*
701 *on the Changes of Physical Activity Relationship (PAR) among Young People Who Are Not*
702 *Very Active* (in Finnish). Nuorisotutkimusverkosto: Nuorisotutkimusseuta verkkojulkaisu
703 115.
- 704 Vasconcellos D, Parker P, Hilland T, Cinelli R, Owen K, Kapsal N, Lee J, Antczak D, Ntoumanis
705 N, Ryan R and Lonsdale C. (2019) Self-determination theory applied to physical education: A
706 systematic review and meta-analysis. *Journal of Educational Psychology*. Epub ahead of print
707 DOI: 10.1037/edu0000420
- 708 Vlachopoulos S, Katartzi E and Kontou M (2011) The basic psychological needs in physical
709 education scale. *Journal of Teaching in Physical Education* 30(3): 263–280.
- 710 Wallhead T, Garn A and Vidoni C (2013) Sport education and social goals in physical education:
711 relationships with enjoyment, relatedness, and leisure-time physical activity. *Physical*
712 *Education and Sport Pedagogy* 18(4): 427–441.
- 713 Wang J, Morin A, Ryan R and Liu W (2016) Students' motivational profiles in the physical
714 education context. *Journal of Sport and Exercise Psychology* 38(6): 612–630.

- 715 Warburton V, Wang J, Bartholomew K, Tuff R and Bishop K (2020) Need satisfaction and need
716 frustration as distinct and potentially co-occurring constructs: Need profiles examined in
717 physical education and sport. *Motivation and Emotion* 44(1): 54–66.
- 718 Williams R (2015) *Imposing and Testing Equality Constraints in Models*. Available at:
719 <https://www3.nd.edu/~rwilliam/stats2/l42.pdf>
- 720 World Health Organization (2018) *Physical Activity*. Available at:
721 http://www.who.int/topics/physical_activity/en/
- 722 Xiang P, Agbuga B, Liu J and McBride R (2017) Relatedness need satisfaction, intrinsic
723 motivation, and engagement in secondary school physical education. *Journal of Teaching in*
724 *Physical Education* 36(3): 340–352.
- 725 Yli-Piipari S, Leskinen E, Jaakkola T and Liukkonen J (2012) Predictive role of physical education
726 motivation: The developmental trajectories of physical activity during grades 7-9. *Research*
727 *Quarterly for Exercise and Sport* 83(4): 560–578.