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8	A one-year follow-up of basic psychological need satisfactions in physical education and
9	associated in-class and total physical activity
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#### 26 Abstract

This study examined basic psychological need satisfactions for competence, autonomy, and social 27 relatedness in physical education (PE) and their contributions to accelerometer-based in-class and 28 total moderate to vigorous physical activity (MVPA) across a one-year follow-up. Participants were 29 523 students (girls 280, boys 243;  $M_{age} = 11.26 \pm .31$ ) and the data were collected using self-reports 30 and waist-worn accelerometers. The key findings were 1) competence and social relatedness need 31 satisfaction at baseline (T0) predicted total MVPA at follow-up (T1) via total MVPA at T0, 2) in-32 class MVPA at T0 predicted total MVPA at T1 via total MVPA at T0, 3) in-class MVPA was 33 directly associated with total MVPA at T0 and T1, and 4) boys scored higher than girls on 34 competence and relatedness need satisfaction at T0. These findings indicate that the need 35 satisfactions for competence and social relatedness in PE are central components facilitating the 36 greatest increases in total MVPA participation. To improve student outcomes, it is essential that all 37 children receive positive and satisfying PE experiences. Enhancing the readiness and capability of 38 pre- and in-service teachers through teacher training programmes is vital to raising awareness of the 39 basic psychological need satisfactions behind autonomous motivation and greater MVPA 40 engagement. 41 42 Keywords 43

44	competence,	autonomy,	social	relatedness,	school,	cross-lagged	model
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#### 51 Introduction

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

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

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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 82 theoretical framework for understanding behavioural processes in the PE context. According to 83 SDT, the basis of motivational behaviour lies in the satisfaction of basic psychological needs for 84 competence, autonomy, and social relatedness (Deci and Ryan, 1985; 2000; Ryan and Deci, 2017). 85 Need for competence refers to the need to be successful in an activity (Ryan and Deci, 2017). 86 Autonomy is the need to engage in activities for growth, volition, and willingness, and social 87 relatedness the need to feel connected and interact with others. If school PE helps students to meet 88 or satisfy these needs by increasing their perceptions of efficacy in given activities (competence), 89 increasing their opportunities to develop interest or value in activities (autonomy), and supporting 90 and encouraging their relationships with their teachers and peers (relatedness), students are likely to 91 be more autonomously motivated (i.e. engage in activities for growth, stimulation, and enjoyment) 92 to participate in PE. In the PE context, some studies have found that competence need satisfaction is 93 the strongest predictor of higher autonomous motivation (Standage et al., 2005; Taylor et al., 2010). 94 Despite this, the current focus in the research literature is the combination of need satisfaction with 95 need frustration (Chen et al., 2015; Ryan et al., 2016; Warburton et al., 2020), as they have been 96 shown to co-occur with differential effects on the outcomes experienced by young people in 97 learning settings such as school PE (De Meyer et al., 2014; Haerens et al., 2013; 2015; Sun et al., 98 2017; Wang et al., 2016). In line with the objectives of the Finnish national PE curriculum (Finnish 99 National Agency for Education, 2014), the present study focused on need satisfactions over 100

101	frustrations, as the satisfactions may have protective effects even when need frustration is
102	experienced (Warburton et al., 2020). Hence, to optimise autonomous motivation in PE, positive
103	need satisfactions could be enhanced (De Meyer et al., 2014; Haerens et al., 2013; 2015; Sun et al.,
104	2017; Wang et al., 2016). Empirical evidence supports this assumption as the need satisfaction for
105	competence (Cox et al., 2008; Gråstén and Watt, 2017), autonomy (Chatzisarantis and Hagger,
106	2009; Lonsdale et al., 2009) and social relatedness (Gråstén and Watt, 2017; Taylor et al., 2010)
107	have been shown to be associated with both total MVPA engagement and in-class MVPA. In
108	addition, associations between in-class and total MVPA have been found in school-based PE
109	studies (Dale et al., 2000; Gråstén et al., 2019).
110	With respect to gender, girls have been found to report less competence (Mouratidis et al.,
111	2015; Ullrich-French and Cox, 2014) and autonomy need satisfaction (Mouratidis et al., 2015; Soini
112	et al., 2007) but more relatedness need satisfaction in PE than boys (Gråstén and Watt, 2017). Some
113	studies have found no gender differences in relatedness satisfaction among school students
114	(Mouratidis et al., 2015; Xiang et al., 2017) or that boys reported higher relatedness need
115	satisfaction than girls (Ntoumanis et al., 2009; Ullrich-French and Cox, 2014).
116	To summarise, the impact of SDT-based motivation in the PE context has been widely
117	researched (De Meyer et al., 2014; Haerens et al., 2013; 2015; Wang et al., 2016). The most
118	relevant application of SDT in PE pedagogy is that a teacher can motivate students to engage and
119	learn in class through supporting need satisfactions (Chang et al., 2016). Intervention studies aimed
120	at increasing students' self-determined motivation in PE are well-documented in the literature
121	(Aelterman et al., 2014; Chatzisarantis and Hagger, 2009; Franco and Coterón, 2017). Of the three
122	needs, most previous intervention studies have aimed at providing autonomy support in PE classes
123	as a way of stimulating students' motivation (Chang et al., 2016). It has also been found that
124	classroom experiences of autonomy and competence in PE are influenced more by teachers than
125	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 126 remain unclear. For example, it is largely unknown how changes in all three basic psychological 127 need satisfactions in school PE contribute to MVPA in PE and, more importantly, to total MVPA 128 over time. A recent review by Vansteenkiste et al. (2020) and a need profile study by Warburton et 129 al. (2020) concluded that more longitudinal work on need satisfactions over time is needed. 130 Previous studies conducted among elementary school children (Ullrich-French and Cox, 2014), 131 secondary school (Ntoumanis et al., 2009; Ratelle and Duchesne, 2014) and university students 132 (Gillet et al., 2019) have revealed considerable heterogeneity in need satisfaction trajectories. 133 This follow-up study extends previous research on the topic by investigating the longitudinal 134 relationships between the three psychological need satisfactions in PE and in-class and total MVPA. 135 In addition to need satisfaction studies with adolescents (Ntoumanis et al., 2009; Ratelle and 136 Duchesne, 2014), it would be also important to examine the longitudinal associations between need 137 satisfactions and MVPA scores over time in elementary school children, as it is at this stage that the 138 decline in physical activity usually begins (Slingerland, 2014; Telama et al., 2005; Tremblay et al, 139 2016). Since boys have been found to be more physically active (Tremblay et al., 2016; Yli-Piipari 140 et al., 2012) and score higher on competence (Fairclough, 2003; Yli-Piipari et al., 2012) and 141 autonomy needs (Mouratidis et al., 2015; Soini et al., 2007) than girls, and conflicting findings have 142 been reported for social relatedness need satisfaction between girls and boys (Gråstén and Watt, 143 2017; Mouratidis et al., 2015; Ntoumanis et al., 2009; Ullrich-French and Cox, 2014; Xiang et al., 144 2017), gender differences were also examined over time. The present findings may be utilised to 145 develop more effective PE teaching practices to fulfil basic need satisfactions, especially in younger 146 children, as it is crucial that children have positive physical activity experiences in PE during their 147 elementary school years (Jaakkola et al., 2019). 148

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

151	MVPA, and total MVPA across a period of one year (Figure 1) and 2) to analyse gender differences
152	in these associations, means, and variances over time. Based on the current literature review, higher
153	satisfaction of the needs for competence, autonomy, and relatedness was expected to be positively
154	linked with higher in-class MVPA and total MVPA at baseline and also at follow-up, although
155	these associations have not been previously investigated in a follow-up design. Positive associations
156	between in-class and total MVPA were also expected. Girls were expected to report higher social
157	relatedness need satisfaction, while boys were believed to score higher on competence and
158	autonomy need satisfaction.
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160	[Figure 1 here]
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162	Methods
163	Participants and procedure
164	Participants were 523 (girls 280, boys 243) Finnish grade five children aged 11 to 13 with a mean
165	age of $11.26 \pm .31$ years at the beginning of the data collection. Children were recruited from 18
166	randomly selected public-sector schools in Southern (26% of students) and Central (74%) Finland.
167	The sample distribution reflects the basic characteristics of Finnish schools (i.e. Finnish-speaking,
168	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 169

and drawing from the same pool of university-trained teachers). Through direct contact with the 170

171 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)

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and 274 (T1). All students participated in regular PE classes (two x 45 minutes of PE per week), no 174

students with special needs participated in the study, although the opportunity was given to all 175

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 181 during the same months in 2018 (T1). Both measurements were implemented using the same 182 procedures. Students answered to the questionnaires in the schools' computer labs or classrooms 183 under the supervision of teachers and researchers. Students were encouraged to answer honestly, 184 and they were assured that their responses were confidential. Children were advised ask for help if 185 needed and told that their participation was optional and that they could withdraw at any time 186 without any consequences. To implement the objective MVPA measurements, researchers entered 187 the students' demographic details and gave them instructions on how to use the activity monitors. 188 Teachers collected the accelerometers and the researchers downloaded the data using the 189 manufacturer's software (Actilife 3.6.0, ActiGraph). Participation was voluntary and was not 190 rewarded with extra credits. Students who returned signed parental consents were permitted to 191 participate in the study. Students who had a medical condition or physical injuries reported by 192 parents before the commencement of the study were excluded. The ethical committee of the local 193 university approved the study. 194

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196 *Measures* 

197 Demographic information was collected during PE classes in the same weeks as the MVPA

198 measurements. Height (130 to 172 cm,  $M = 148 \pm 7$  cm) and weight (26 to 76 kg,  $M = 41.5 \pm 8.5$ 

199 kg) were measured. Body mass index (14 to 33,  $M = 19 \pm 2.9$ ) was calculated (kg/m<sup>2</sup>) 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

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201 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. 202 The Finnish version of the Basic Psychological Needs in Physical Education Scale (BPN-PE; 203 204 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 205 12 items divided among three subscales: competence (e.g. I can do well even in the lessons 206 considered difficult by most kids in my class), relatedness (e.g. my relationships with the other kids 207 in my class are friendly), and autonomy (e.g. we do things in class that interest me). All three 208 subscales were measured on five-point response scales from (1) totally disagree to (5) totally agree. 209 Gråstén et al. (2019) reported acceptable construct validity for the Finnish version ( $\gamma 2(50) = 106.59$ , 210

211 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+ 213 accelerometers. Total MVPA was collected across a period of seven days, and in-class MVPA was 214 extracted from total MVPA. During the measurement period, students participated in two PE 215 classes (two x 45 minutes) following the local curriculum. The activity monitors were light, small, 216 easy to use, and were worn on the right waist. The devices collected the data at 15-second intervals, 217 as longer sampling intervals might have been inaccurate with young children (Nilsson et al., 2002). 218 Only daytime activity (7am to 11pm), excluding water-based activities as the accelerometer model 219 used was not waterproof, was included in the analyses. Following the protocol adopted in the earlier 220 studies of Bergh et al. (2011) and Gråstén and Watt (2016), total MVPA minutes were considered 221 valid if a child had at least three days, including one PE class and one weekend day, with at least 222 500 minutes of activity recorded per day. Periods of 30 minutes of consecutive zero counts were 223 defined as non-wear time (Heil et al. 2012). The lower threshold for moderate-intensity activity was 224

225 2296 counts per minute (Evenson et al., 2008). The device used has previously been calibrated for
226 young people in laboratory and free-living conditions (Martinez-Gomez et al., 2012).

227

#### 228 *Statistical analyses*

Data were examined for normality of distributions, outliers (Tabachnick and Fidell, 2007) and 229 missing values (Little and Rubin, 2002). Next, descriptive statistics, including correlations, means 230 and standard deviations for the study variables, were determined. Since the data were expected to be 231 hierarchical, intraclass correlation coefficients were calculated to detect variation in the study 232 variables between classes and schools (Koo and Li, 2016). To examine the direct and indirect 233 associations between the competence, autonomy, and relatedness need satisfactions, MVPA in PE, 234 and total MVPA, a cross-lagged model using latent variables was estimated. A complex option with 235 236 maximum likelihood estimation and robust standard errors was used to correct the possible nonindependence of observations based on students being nested within their classes (Asparouhov, 237 2006). Gender differences in the loadings between paths from T0 and T1, means, and variances 238 were tested using two-group tests based on Chi-square, in which two nested models can be 239 examined by constraining the subsequent parameters to be equal (Muthén and Muthén, 2013). 240 Equality of means between repeated measurements at T0 and T1 were tested using the Wald's test 241 of parameter equality (Williams, 2015). 242

The Chi-square test (χ2) 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.

253

#### 254 **Results**

255 *Preliminary analysis* 

Data were normally distributed, and no significant outliers were detected based on the standardized 256 values ( $\pm$  3.00). The data matrix included 15.79% of missing values (826 out of 5230), owing to 257 258 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 259 closer examination of the data supported that missing values were missing completely at random, as 260 the missing scores did not represent any particular school or group. Missing values were then 261 estimated using the Full Information Maximum Likelihood Estimation method, which has been 262 shown to produce unbiased parameter estimates and standard errors under MCAR conditions 263 (Enders and Bandalos, 2001). 264

265

#### 266 *Descriptive statistics*

The correlation coefficients, means, standard deviations, and Cronbach alphas for the study 267 variables were examined (Table 1). The correlations between variables ranged from weak to strong. 268 The strongest positive correlation was found between the autonomy and relatedness need 269 satisfactions at T1. The mean difference tests between the T0 and T1 measurements revealed that 270 autonomy need satisfaction, MVPA in PE and total MVPA declined in girls and that competence, 271 autonomy, relatedness satisfactions and total MVPA declined in boys over time (Table 2). The 272 proportions of children meeting the current MVPA guidelines varied over time (girls 38% at T0 and 273 29% at T1; boys 54% at T0 and 49% at T1), with total MVPA minutes per day ranging from 16 to 274

275	128 (T0) and 17 to 114 (T1) in girls and 11 to 129 (T0) and 19 to 119 (T1) in boys. The intraclass
276	correlation coefficients showed no variation between classes or schools in competence, autonomy
277	or total MVPA and low to moderate variations in relatedness at T1 and in-class MVPA at T0 and
278	T1 (Table 3). Because MVPA in PE was indicated to have a multilevel structure, the following
279	cross-lagged model was implemented using the complex model option to adjust for sampling
280	weights (Asparouhov, 2006).
281	
282	[Table 1 here]
283	[Table 2 here]
284	[Table 3 here]
285	
286	Associations between basic psychological need satisfactions and MVPA
287	First, to examine the appropriateness of the theorised measurement model including needs for
288	competence, autonomy, relatedness, MVPA in PE, and total MVPA at T0 and T1, both girls and
289	boys were combined as a single group in the same model. The theorised model revealed an
290	acceptable model fit ( $\chi^2(329) = 666.54$ , $p < .001$ , $CFI = .93$ , $TLI = .92$ , $RMSEA = .044$ , 90% $CI$ [.04,
291	.05], $SRMR = .046$ ). The model showed significant direct and indirect paths between the study
292	variables (Figure 2). Squared multiple correlations $(R^2)$ showed that the model explained 19% to
293	35% of the variability of total MVPA and 9% of the variability of in-class MVPA, excluding the
294	non-significant squared multiple correlation of in-class MVPA at T0.
295	
296	[Figure 2 here]
297	
298	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 299 implemented by fixing the loadings between T0 and T1 to be equal. Significant gender differences 300 emerged in the loadings between social relatedness satisfaction at T0 and T1 ( $\gamma^2(1) = 4.45$ , p < .05) 301 and social relatedness satisfaction at T1 and total MVPA at T1( $\chi^2(1) = 4.29$ , p < .05), specifically 302 between relatedness T0 and relatedness T1 (girls = .52, boys = .60) as well as relatedness T1 and 303 total MVPA T1 (girls = -.05; boys = .18). To test the equality of means and variances to identify 304 significant differences between girls and boys, a series of two-group tests was implemented. The 305 results showed that boys scored higher than girls on competence at T0 ( $\gamma^2(1) = 14.86$ , p < .001) and 306 relatedness need satisfaction at T0 ( $\chi^2(1) = 5.59$ , p < .05) and that gender differences existed in in 307 the variances of social relatedness satisfaction at T0 ( $\chi^2(1) = 5.60$ , p < .05) and in-class MVPA at 308 T1 ( $\chi^2(1) = 12.74, p < .001$ ). 309

310

#### 311 Discussion

This study investigated the associations between the satisfaction of basic psychological needs for 312 competence, autonomy, and social relatedness, MVPA in PE, and total MVPA. The study also 313 examined gender differences over time. Based on the current SDT literature in the area, higher 314 satisfaction of the needs for competence, autonomy, and relatedness was expected to be linked with 315 higher in-class MVPA, and total MVPA at baseline. Although a few previous studies in the SDT 316 literature have presented need satisfaction trajectories over time (Ntoumanis et al., 2009; Ratelle 317 and Duchesne, 2014; Ullrich-French and Cox, 2014), no studies investigating need satisfactions 318 over time have concurrently examined competence, autonomy, and relatedness in the domain of 319 physical activity. Thus, this study contributes to the literature on the topic by examining how 320 changes in all three basic psychological need satisfactions in PE contribute to MVPA in PE and to 321 total MVPA over time. As expected, the positive paths from competence need satisfaction, social 322 relatedness need satisfaction, and in-class MVPA to total MVPA as well as gender differences in 323

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.

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

likely to be similar across cultures (Chen et al., 2015), strategies introduced to support competence 349 satisfaction in PE classes may best work in Finnish or other less authoritarian school systems. In the 350 Finnish school system, relationships between teachers and students tends towards informality, 351 meaning that students find it easy to approach their teachers (Kauppi and Pörhölä, 2012). In school 352 cultures with more formal teacher-student relationships, such methods may need some 353 modification. As supporting competence need satisfaction in PE classes appears to be important in 354 ensuring positive MVPA engagement over time, it would be crucial to identify students, whose 355 level of competence satisfaction is low. This may be even more valuable than viewing the transition 356 over time itself as a risk for poor student outcomes (Ullrich-French and Cox, 2014). 357 Second, in line with previously established associations (Gråstén and Watt, 2017; Taylor et 358 al., 2010) social relatedness satisfaction at baseline was related with total MVPA at follow-up via 359 baseline MVPA. Children who reported positive relatedness need satisfaction when engaged in PE 360 activities were generally more physically active. This finding underlines the importance of the 361 social aspects of PE lessons for total MVPA engagement. To support social relatedness need 362 satisfaction across PE lessons, students could be given opportunities in their learning teams to 363 develop their content knowledge and refine their performance through peer teaching instructional 364 tasks (Standage and Ryan, 2012; Wallhead et al., 2013). Furthermore, students could be provided 365 with a well-structured environment that gives clear guidelines (open teacher-student 366 communication) and opportunities for social learning (cooperation between students), provides 367 optimal challenges, and offers detailed feedback on how to achieve desired outcomes (Taylor and 368 Ntoumanis, 2007). Given that some previous studies have revealed direct associations between 369 larger class sizes and higher levels of antisocial behaviour (Reeves, 2010), class sizes should be 370 judiciously considered, when grouping PE students. If classes are too large, the PE teacher does not 371 have enough time to give detailed student feedback as a way of optimising learning outcomes. All 372 such improvements rely on good cooperative working arrangements between teachers, students, and 373

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

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

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399 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 400 their own way), and acknowledge and accept students' expressions of negative affect (treat 401 students' complaints as valid reactions to imposed demands and structures). Although it is difficult 402 to explain the current negative association, it might, based on previous research findings, be fruitful 403 to promote autonomy in curriculum-based activities in PE classes. If successful, this is likely to 404 translate into higher total MVPA scores, which is needed across the life-span (Tremblay et al., 405 2016). 406

The results also showed the importance of MVPA in PE classes and its contribution to total 407 MVPA engagement. As expected, baseline MVPA in PE classes predicted total MVPA at follow-408 up. Specifically, in-class MVPA accounted, on average, for 37% of total MVPA in all students over 409 the study period. This result supports previous Finnish (Gråstén et al., 2015; 2019) and international 410 (Bailey et al., 2012) findings. The present total MVPA scores indicated that children's MVPA 411 levels were insufficient, which is a matter of great concern. Many potential strategies can be 412 deployed to increase the amount of MVPA time in PE classes. Schools could, for instance, review 413 class sizes, reduce time spent in locker rooms, and implement instant activities instead of sitting and 414 waiting for instructions at the beginning and end of the class (McKenzie et al. 2000), establish 415 routines for the more efficient supply of equipment by letting students assist with the care and 416 proper storage of PE teaching materials (Gråstén et al., 2017), integrate objective devices into PE 417 classes to monitor MVPA behaviour (Strand and Reeder, 2013), and reassess MVPA time and use 418 the results to refine and improve practice (Freedson et al., 2012; McKenzie et al. 2000). It is clear 419 that students need more MVPA than schools alone can provide. Hence, ensuring that they have 420 satisfying and positive PE experiences may facilitate the adoption of a more active lifestyle outside 421 of PE. 422

Finally, in line with previous studies (Mouratidis et al., 2015; Ullrich-French and Cox, 2014), 423 boys had higher baseline competence need satisfaction. Contrary to some previous evidence, boys 424 also had higher baseline social relatedness need satisfaction than girls. Compared to an earlier 425 Finnish study reporting opposite results (Gråstén and Watt, 2017), it is possible that the boys in the 426 present sample experienced more opportunities to interact with peers in out-of-school activities. If 427 so, they may also manifest as higher social relatedness satisfaction scores in PE classes. However, 428 Howie et al. (2010) reported that children who participated more frequently in sports had higher 429 social skill scores than those who participated less frequently in sports. This may also explain the 430 differences between groups in the current study. Many previous studies have reported that 431 interaction with peers plays a critical role in the development of children's social competence 432 433 (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 434 appearance, physical development, and bodily changes in early adolescent girls appear to be 435 associated with negative perceptions of social relatedness (Craft et al., 2003). If so, this may be 436 reflected in the present lower scores in girls. It has been suggested that perceptions of social 437 relatedness among adolescent girls may be enhanced by emphasizing friendship and social 438 interaction in PE classes and minimising social comparisons (Craft et al., 2003). According to 439 Gibbons (2014), a socially supportive learning environment in PE could be created by including 440 cooperative games and team-building activities, helping students to develop connections with 441 teachers and peers (learn the names of your students, use icebreakers), using group rotation (by the 442 end of the semester everyone has worked with everyone else), reinforcing positive behaviour, 443 avoiding stereotypical language ("girls' push-ups"), asking students how to create a safer 444 environment, and implementing a respectful process of choosing teammates (you must accept the 445 first person who responds, if someone does not have a group invite them into your group). Thus, 446 there are many practical ways of enhancing social interaction in PE lessons. 447

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#### 449 *Limitations and future research directions*

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

464

#### 465 **Conclusion**

The present results showed the importance of in-class MVPA and its contribution to total MVPA engagement. To increase the amount of daily MVPA time, it would seem to be crucial to support the need satisfactions for competence and social relatedness in PE classes. This is especially important among girls, as they normally accrue fewer daily MVPA minutes than boys. An increased use of need-centred teaching strategies could promote student engagement in the PE context. 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 472 relatedness, in-class MVPA and, most importantly, total MVPA engagement over the long term 473 Concerns arising from these findings were that total MVPA declined over time in both girls 474 and boys, and a smaller proportion of children met the current MVPA guidelines at follow-up. 475 Schools alone cannot provide all the MVPA children need. To help children achieve a physically 476 active lifestyle later in their lives, it is essential to ensure that all students enjoy positive and 477 satisfying PE experiences. To raise awareness of the basic psychological need satisfactions and 478 improve student outcomes, it would be vital, through teacher training programmes, to enhance the 479 readiness and capability of pre-service teachers, as they will play a crucial role in stimulating 480 autonomous motivation and greater MVPA engagement. 481 482 483 Acknowledgements Authors want to thank Professor Richard Ryan (Institute for Positive Psychology and Education, 484 Australian Catholic University) for pre-reviewing the first version of this manuscript. 485 486 **Declaration of conflicting interests** 487 The authors declare no potential conflicts of interests with respect to the research, authorship, 488 and/or publication of this article. 489 490 491 Funding 492 This study was financially supported by the Finnish Ministry of Education and Culture and the Otto A. Malm Foundation, Finland. 493 494 495 496

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