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**Antecedents and mediators of the association between adolescents' intention and physical activity: a cross-sectional study in seven European countries**

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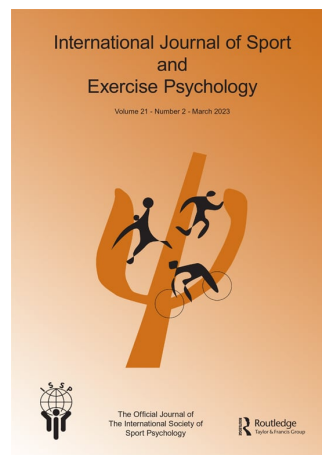
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### Abstract

About 80% of adolescents report insufficient physical activity (PA) worldwide. Beyond the association of attitudes, family and friends' support, and perceived behavioural control (PBC) with intention, self-regulation strategies are expected to underlie the association between intention and action. Particularly, action planning and self-monitoring, as well as the perceived energy needed to develop these strategies, may explain the relationship between intention and PA. However, existing evidence remains scarce and contrasted among adolescents. In a large sample of 13136 adolescents from seven European countries, we examined the antecedents of intention. We further investigated whether action planning and self-monitoring mediated the association of intention with self-reported PA, as well as whether perceived energy predicted PA through these self-regulation strategies. Structural equation modeling showed that attitudes, PBC, family and friends' support were all associated with intention ( $b > 0.08$ ,  $p < .001$ ). Intention (direct effect,  $b = 0.23$ ,  $p < .001$ ) and PBC were associated with PA ( $b = 0.22$ ,  $p < .001$ ). Action planning (indirect effect,  $b = 0.06$ ,  $p < .001$ ) and self-monitoring (indirect effect,  $b = 0.10$ ,  $p < .001$ ) partly mediated the relationship of intention with PA. Perceived energy was associated with PA through the partial mediating effect of action planning (indirect effect,  $b = 0.05$ ,  $p < .001$ ) and self-monitoring (indirect effect,  $b = 0.11$ ,  $p < .001$ ). Our results suggest that both action planning and self-monitoring underlie the association between intention and PA among European adolescents and that perceived energy could be an antecedent of these self-regulation strategies.

*Keywords:* Physical activity, intention, self-regulation, action planning, self-monitoring.

## **Antecedents and mediators of the association between adolescents' intention and physical activity: a cross-sectional study in seven European countries**

Despite extensive benefits on physical, cognitive and mental health (e.g., Poitras et al., 2016), many adolescents do not reach recommended levels of physical activity: about 80% of them are considered physically inactive worldwide (Guthold et al., 2020), with alarming trends being observed across the last decades (Conger et al., 2022). Further, given the positive association between the physical activity levels in which adolescents engage and their levels observed in later adulthood (Batista et al., 2019), adolescence seems to represent a critical period in shaping an active and healthy lifelong lifestyle. To tackle this pandemic of physical inactivity, identifying motivational factors explaining adolescents' engagement in physical activity is thus warranted, as these precursors could serve as potential targets for future interventional studies.

### **The theory of planned behaviour**

When predicting PA, dominant motivational theories share the common assumption that intention (or goals) constitutes a prerequisite for behavioural engagement (Rhodes et al., 2019). Prominent among these motivational theories is the theory of planned behaviour (Ajzen, 1991). According to this theory, attitudes (i.e., the degree to which the performance of a certain behaviour is positively or negatively valued), perceived behavioural control (PBC) (i.e., perceptions of one's ability to perform a certain behaviour) and subjective norms (i.e., perception of social pressure from significant others, such as family or friends, to engage in a certain behaviour) shape the intention to engage in a certain behaviour. Previous research conducted among youth highlights that subjective norms provide a narrow focus on social influence as it mostly reflects social pressures (Ajzen, 1991), at the expense of social support that can be provided by either family or friends. As an extension of the theory of the planned

behaviour, considering the relative contribution of family and friends' social support on adolescents' physical activity was thus encouraged by previous research (Hamilton & White, 2008) – an effort we aimed to pursue in this article.

The core premise of theory of planned behaviour is that intention constitutes the most proximal antecedent of behaviours (e.g., physical activity). Moreover, beyond its effect through intention, PBC is also expected to be directly associated with behaviours. This theory has received extensive empirical support in physical activity, both among adults and adolescents (e.g., Hagger et al., 2002). Particularly, meta-analyses confirmed that attitudes, subjective norms (that will be replaced by social support in our study), and PBC together explained intention, whereas intention and PBC were both positively associated with physical activity (e.g., Hagger et al., 2002).

### **The intention-action gap**

Despite predicting physical activity behaviours to some extent (McEachan et al., 2011), it has also been shown that the theory of planned behaviour predicts greater variance in intention than in behaviours. For example, a meta-analysis revealed that a medium-to-large change in intention only resulted in a small-to-medium change in behaviour (Webb & Sheeran, 2006). Indeed, as more broadly observed, individuals often hold the intention to be physically active but half of them fail to translate this intention into action (Rhodes & de Bruijn, 2013). Of note, this intention-action gap was also evidenced regarding youth's physical activity, with empirical evidence consistently showing that the strength of the association between intention and behaviours was weaker among adolescents than among adults (Hagger et al., 2002). A study also showed, among 9- to 11-year-old participants, that despite an overall high intention to be physically active every day, only 13% described themselves as doing at least seven 30-minute bouts of physical activity by week (Rhodes et al., 2006). Accordingly, additional constructs have been gradually incorporated in theoretical models to shed light on the mechanisms that

may favor the enactment of intention into action (e.g., Schwarzer & Luszczynska, 2008). In particular, anchored within a self-regulation tradition (Carver & Scheier, 1982), the so-called hybrid models integrates post-decisional variables – here referred as self-regulation strategies – alongside with intention to explain the intention-action relationships (e.g., Schwarzer & Luszczynska, 2008).

### **Self-regulation strategies**

Among these constructs, action planning<sup>1</sup> and self-monitoring have both shown promising beneficial effects on physical activity, especially when combined (Michie et al., 2009). Action planning and self-monitoring are assumed to play a complementary role on the translation of intention into action as they refer to two different and successive phases of self-regulation processes (Baumeister et al., 1994). Action planning corresponds to a forward-looking strategy, through which individuals anticipate where, when and how to perform a desired behaviour (e.g., “On Friday, directly after school, I will go playing football with my friends”) (Sniehotta, Schwarzer, et al., 2005). In contrast, self-monitoring refers to a self-regulatory strategy that can be implemented retrospectively or concurrently (i.e., while the behaviour is ongoing). Specifically, when self-monitoring, individuals estimate the current discrepancy between their intention (or goals) and their current behaviours (e.g., “I want to make at least 8000 steps by day, but my smartphone app indicates that I am still missing 1000 steps”), which may, in turn, lead them to actively reduce this discrepancy by forming new action plans (e.g., “So I will get out of the bus earlier tonight and walk back home”) (Sniehotta, Schwarzer, et al., 2005).

Because adolescents report difficulties in translating their intention to be active into intention into behaviours, they may particularly benefit from the use of these self-regulation strategies. However, despite their potential relevance and of this potential synergistic role, only few studies have been conducted in this population and most of them either focused on the role



of action planning or on the role of self-monitoring. As such, the relative association of action planning and self-monitoring with physical activity remains almost unexplored among adolescents (see Nurmi et al., 2016 for an exception)

### **The effectiveness of self-regulation strategies among adolescents**

As supported by experimental studies, action planning may underlie the association between intention and action by proactively building well-learned associations between critical situational cues (e.g., after school) and goal-directed behaviours (e.g., playing football with my friends) (Gollwitzer & Sheeran, 2006). After this learning phase, behaviour is assumed to be rather automatically elicited, as a response to encountering the related cues (Maltagliati et al., 2022). Yet, in the field of PA and among adolescents, some transversal studies reported positive associations between action planning and physical activity (Gerber et al., 2015), whereas non-significant associations were observed when intention was controlled for (e.g., Nurmi et al., 2016). In sum, correlational evidence among adolescents remains quite scarce in number and rather inconsistent. Shedding new lights on the potential associations between action planning and physical activity seems warranted.

Self-monitoring is also expected to favor the translation of intention into action. In particular, by actively seeking to reduce the perceived discrepancy between an intention and one's current behaviour, individuals are expected to develop new actions plans and new self-monitoring until the goal is completed (Carver & Scheier, 1982). The beneficial effect of this strategy on physical activity was supported among adolescents, through both interventional and prospective studies (Matthews et al., 2018; Nurmi et al., 2016). Still, the low number of studies examining the effect of self-monitoring on physical activity encourages further investigation on this association, especially given the potential of this strategy among adolescents. Critically, as mentioned above, the association of self-monitoring with physical activity was mostly examined in isolation from that of action planning, preventing us to determine whether both

strategies remain associated with physical when controlling for each other. Only Nurmi et al., (2016) revealed that action planning was no longer associated with adolescents' physical activity, once self-monitoring was controlled for. Because action planning and monitoring refer to two different phases of self-regulation processes (Baumeister et al., 1994), identifying the relative role of these two self-regulation strategies in physical activity may thus deepen our understanding of the processes underlying the link between adolescents' intention and action.

### **Perceived energy as an antecedent of self-regulation strategies**

Yet, developing such self-regulation strategies may not be straightforward for adolescents who gradually need to learn to organize their physically active behaviours. In this perspective, another overlooked avenue of research concerns the factors which promote the development of action planning and self-monitoring. One potential precursor involved in the development of these self-regulatory strategies is perceived energy (Forestier et al., 2022), corresponding to the perceived amount of energy available to the regulatory control of one's self (Ryan & Frederick, 1997). Indeed, developing self-regulatory strategies involve deliberative, reasoned and effortful processes (Hagger & Luszczynska, 2014). For example, although it is assumed to prompt an automatic behavioural instigation once developed, prospectively planning where, when and how to engage in physical activity behaviours can be seen as particularly effortful, as it involves a set of rather complex decisions, especially among adolescents who sometimes perceive action planning as something coercive or unpleasant (Renko et al., 2022). In support of this hypothesis, it has been shown that a higher level of perceived energy was positively associated with physical activity (Cheval et al., 2021; Hevel et al., 2021), including among youth (Dunton et al., 2014). Particularly, perceived energy has been shown to positively predict physical activity by reducing the strength of desires toward sedentary behaviours, suggesting an active role of energy in self-regulating own's behaviours (Forestier et al., 2018). Yet, these last studies did not identify the potential mechanisms

underlying the relationship between feelings of energy and engagement in physical activity. We here contend that perceiving energy would drive the development of action planning and self-monitoring, which would in turn trigger adolescents' engagement in physical activity.

### **The current study**

Drawing upon a large-scale sample of adolescents from seven European countries, the purpose of this study was to examine the associations of variables stemming from the theory of planned behaviour (i.e., attitudes, PBC, family and friends' support, intention) with adolescents' intention to be physically active. A step further, we aimed to investigate the mediating effect of self-regulation strategies (i.e., action planning and self-monitoring) on the association between intention and physical activity. A last objective was to investigate whether perceived energy was positively associated with action planning and self-monitoring – two deliberative and effortful self-regulatory strategies (Figure 1A).

Regarding the first objective and in line with the theory of planned behaviour, we hypothesized that attitudes, PBC, family and friends' support would positively predict the intention to be physically active (H1). Moreover, we expected that PBC would be directly associated with physical activity behaviours (H2). Regarding our second objective, grounded in the self-regulation literature, we hypothesized that action planning and self-monitoring would both mediate the association between intention and physical activity (H3). Finally, we predicted that perceived energy would predict both action planning and self-monitoring and therefore that these two variables would mediate the relationship between perceived energy and physical activity (H4).

## **Methods**

### **Participants and procedure**

Data were collected within a European-wide project, whose background, aims and methods were extensively described elsewhere on the following website:

<http://www.impactpe.eu/>. Adolescents from seven European countries (France, Greece, Italy, Portugal, Spain, Turkey and the United Kingdom) in middle or high school were invited to complete a questionnaire on their physical activity behaviours. Of note, before participating, adolescents under 18 years old had to return a written consent signed by their parents or legal responsible. Adolescents were offered the possibility to participate in this study by their Physical Education teacher, who was instructed on how to introduce the study, as well as on the study procedure. A researcher could also assist teachers, if requested. Teachers proposed volunteers to participate in the study outside of Physical Education hours, but still during school hours in order to be present during the completion of the questionnaires. Students answered the questionnaire on computers or on tablets and took between 30 minutes and one hour to complete it.

In total, 13359 participants were included in the study. We included participants who provided minimal sociodemographic information (i.e., age, country, sex), resulting in a sample of 13136 participants (52% of female adolescents, mean age =  $13.8 \pm 2.0$  years). In total, the sample was composed of 1181 French, 3031 Greek, 2531 Italian, 1003 Portuguese, 1333 Spanish, 3371 Turkish and 686 United Kingdom adolescents. Table 1 reports sociodemographic information, stratified by country. Participants provided written consent before completing the questionnaire and were fully debriefed after its completion. This study was approved by local ethics committee for each country involved.

## Measures

*Attitudes* toward physical activity were assessed using four items used by (Hagger et al., 2009). Participants were invited to indicate their feelings about practicing physical activity at least three times a week, for 60 minutes each time (i.e., bad vs good, boring vs interesting, useless vs useful, unpleasant vs pleasant). Answers were given on bipolar scales ranging from 1 to 7.

**Social support** was measured by eight items (Dewar et al., 2013), with four items assessing family support and four assessing friends' support. After the stem "In the past 3 months how often [...]", participants were asked to rate the frequency with which friends and family reinforced PA through encouragement, role modeling, and the provision of PA opportunities, starting (e.g., did your family/your friends participate in physical activity/sports with you?). Answers were reported on a five-point Likert scale ranging from 1 (Never) to 5 (Always).

**Perceived behavioural control** was captured by three questions (Hagger et al., 2009), with participants being asked to indicate to what extent they felt confident and they felt they had control over their physical activity levels (e.g., How much control you have over doing sports/exercise in your leisure time at least 3 times a week, 60 minutes each time in the next month?). Answers were given on a seven-point scale ranging from 1 (Not agree at all) to 7 (Totally agree).

**Intention to be physically active** was measured using three items (Standage et al., 2003). The questions were formulated to correspond to a behavioural criterion in time, context, target and action (e.g., Over the next month, I am determined to exercise/ play sport, at least three times a week, for 60 minutes each time). Answers were reported on a seven-point scale ranging from 1 (Very unlikely) to 7 (Very likely).

**Action planning** was assessed using a five-item scale developed by (Sniehotta, Scholz, et al., 2005). Participants had to indicate to which extent they had specific plans about when, where, how, how often and with whom, to engage in physical activity, over the last three-four weeks (e.g., I have planned when to do sport/exercise). Participants answered on a five-point scale ranging from 1 (Never) to 5 (Very often).

**Self-monitoring** was captured using four items adapted from two previous scales (Sniehotta, Scholz, et al., 2005; Theodosiou & Papaioannou, 2006). As for action planning,

participants rated to which extent they had self-monitored their physical activity level, over the last three-four weeks (e.g., I have watched carefully that I did sport/exercise in my leisure time for at least three times a week, for 60 minutes each time). Answers were reported on a five-point scale spanning from 1 (Never) to 5 (Very often).

***Perceived energy*** was indexed by subjective vitality and measured using a five-item version validated for adolescents (Papaioannou et al., 2013) of the original scale developed Ryan & Frederick (1997). Participants were asked to indicate how they felt over the past month (e.g., I felt full of vitality) and answers were given on a five-point Likert scale ranging from 1 (Strongly disagree) to 5 (Strongly agree).

***Self-reported physical activity*** was estimated using eight items which were respectively expected to tap onto a different facet of adolescents' physical activity behaviours. First, adolescents completed a two-item scale (Prochaska et al., 2001) assessing how many days per week (from 0 to 7 days) they engaged in physical activity for at least 60 minutes per day during the last seven days and during a usual week, respectively. Second, using a single item (Booth, 2001), they indicated how many hours per week (from 0 to 7 hours) in their free time they engaged in physical activity so much that they get out of breath or sweat. Then they completed the Youth Activity Profile, a self-reported instrument designed to capture physical activity and sedentary behaviour in youth (Saint-Maurice & Welk, 2014). In this study, only the five items designed to capture out-of-school physical activity were used. Three items measured the number of days (from 0 to 4/5 days) that participants engaged in physical activity for at least 10 minutes at different times of the day across the previous week: in the morning (before school), just after school, and on weeknights. The last two items assessed physical activity on Saturday and Sunday respectively (from 0 to more than two hours). Finally, they reported how many days per week they engaged in sport or structured physical activities that were led by a coach, instructor or leader (from 0 to 5 or more). As abovementioned, a latent score was created

to reflect an overall estimation of physical activity over the last weeks across different contexts of free time. This scoring procedure was validated in another ongoing study from our research group by estimating its correlation with a concurrent accelerometer-based measure of physical activity in a subsample of Greek adolescents.

### **Statistical analyses**

Given the cross-cultural nature of this study, we carried out multigroup analyses in order to test measurement invariance between countries, in an effort to establish the comparability of measurement models across sampled populations (Milfont & Fischer, 2010). Different forms of invariance (i.e., configural, metric and scalar) were sequentially tested. To examine configural invariance (i.e., whether the pattern of the items loadings is equivalent across samples), we first computed a baseline model in which latent variables were specified using the different items. After specifying our model, the goodness of its fit was estimated based on the comparative fit index (CFI) and the root mean square errors of approximation (RMSEA), with a CFI > .90 and RMSEA < .08 being indicative of an acceptable fit (Brown, 2006). Then, to respectively examine metric (i.e., whether the magnitude of factor loadings on a latent variable was equivalent across samples) and scalar invariance (i.e., whether intercepts were equivalent across samples for a same score on the latent variable), we constrained factor loadings and intercepts of items to be the same across samples. We compared the differences in CFI ( $\Delta$ CFI) and RMSEA ( $\Delta$ RMSEA) across models, with a  $\Delta$ CFI  $\leq$  .01 and  $\Delta$ RMSEA  $\leq$  .015 indicating that the null hypothesis of invariance should not be rejected (Chen, 2007). Assuming that one type of invariance was not established, we investigated the source of invariance by sequentially releasing factor loadings and/or intercepts of items and by retesting the model until reaching a partially invariant model (Putnick & Bornstein, 2016).

Then, to test our hypotheses, we computed a latent structural model in which we entered hypothesized paths between latent variables. In this model, to obtain a global estimate of

associations across countries, path coefficients were constrained to be equal across countries (i.e., constrained model). Accordingly, we report a unique unstandardized beta coefficient ( $b$ ) and its 95% confidence interval (95CI) by path across countries, an estimate on which a statistical inference can be made. To examine the mediating effect of action planning and self-monitoring on the association between intention and physical activity, we adopted the component approach (Yzerbyt et al., 2018). According to this approach, a significant indirect effect is supported when the two paths of the indirect effect (i.e., from the independent variable to the mediating variable [a path] and from the mediating variable to the dependent variable [b path]) are significant ( $p < .05$ ). In comparison with bootstrapped approaches (e.g., single test of a mediational index), this approach is expected to reduce risks of Type 1 errors, while preserving statistical power (Yzerbyt et al., 2018).

Finally, we computed multigroup analyses to examine whether path coefficients between the different variables were invariant across countries. Assuming that the unconstrained model (i.e., in which all paths were allowed to vary across countries) showed a better comparative fit to the data than the abovementioned constrained model (i.e., lower BIC, AIC,  $\chi^2$  [with  $p$ -values  $< .05$ ]) (Bollen et al., 2014), a step-by-step approach was adopted to identify which paths differed across countries and needed to be released.

To account for missing data, all models were specified using a full information maximum likelihood (FIML) estimator – an approach that allows to estimate more accurate parameters based on available data (Enders & Bandalos, 2001). All analyses were conducted using R (version 4.4), with the *lavaan* package (Rosseel, 2012).

### **Sensitivity analysis**

We conducted a sensitivity analysis in which only participants who had fully completed the questionnaire were included ( $N = 7648$ ), resulting in a drop of 5488 participants relatively to main analyses. In a second sensitivity analysis, models were adjusted for students' school in



order to account for clustering effects that may result from educational factors or local neighborhood factors and that may confound observed associations. This analysis was conducted using the lavaan.survey package that allows to control for clustering effects in structural equation models (Oberski, 2014). Only schools with at least 20 students were retained in the analyses (Meuleman & Billiet, 2009), resulting in a total of 11084 students from 198 different schools.

## Results

Descriptive statistics and bivariate correlations are reported for the overall sample in Table 2 and by country in Table 3. Overall, participants reported rather high scores for attitudes, PBC and intention, and scores slightly above the midpoint of the scale for the other motivational variables. All bivariate correlation coefficients were significant ( $p < .001$ ). We observed correlations between theory of planned behaviour variables (i.e., attitudes, family and friends support', PBC, intention), ranging from  $r = .28$  to  $r = .64$  ( $p < .001$ ). Moreover, PBC, intention, action planning and self-monitoring were all correlated with physical activity ( $.42 < r < .58$ ;  $p < .001$ ). Intention and perceived energy were associated with action planning and self-monitoring ( $.43 < r < .56$ ;  $p < .001$ ).

Regarding measurement invariance (Table 4), configural invariance was supported with CFI = .946 and RMSEA = .043. When constraining factor loadings across samples, metric invariance was also supported, with  $\Delta\text{CFI} = .006$ ,  $\Delta\text{RMSEA} = -.001$ . However, when constraining intercepts across samples, scalar invariance was not supported, with  $\Delta\text{CFI} = .034$  and  $\Delta\text{RMSEA} = -.01$ . As planned, we sequentially released intercepts across countries, until achieving a  $\Delta\text{CFI} < .01$  and a  $\Delta\text{RMSEA} \leq .015$ . After sequentially releasing 17 intercepts on the 39 possible, corresponding to an acceptable ratio (Putnick & Bornstein, 2016), we achieved a partially invariant model ( $\Delta\text{CFI} = .010$  and  $\Delta\text{RMSEA} = -.003$ ), which was retained as our measurement model in subsequent analyses.

Next, we ran a model in which the paths between the latent variables were entered and were constrained to be equal across countries (i.e. a constrained multi-group model). When entering these paths between latent variables, this constrained structural model showed acceptable fit to the data (CFI = .92, RMSEA = .049). The unstandardized beta coefficients (b) of this model are presented on Figure 1B. To provide effect sizes of these associations, standardized beta coefficients ( $\beta$ ) and explained variance ( $R^2$ ) are reported in Table S1.

Attitudes ( $b = 0.20$ , 95CI = [0.16; 0.24],  $p < .001$ ), family support ( $b = 0.20$ , 95CI = [0.16; 0.24],  $p < .001$ ), friends' support ( $b = 0.08$ , 95CI = [0.04; 0.11],  $p < .001$ ) and PBC ( $b = 0.86$ , 95CI = [0.77; 0.95],  $p < .001$ ) were associated with intention.

PBC ( $b = 0.22$ , 95CI = [0.18; 0.26],  $p < .001$ ), was positively associated with physical activity. Intention was positively associated with action planning ( $a_1$  path,  $b = 0.46$ , 95CI = [0.41; 0.50],  $p < .001$ ) and with self-monitoring ( $a_2$  path,  $b = 0.42$ , 95CI = [0.38; 0.47],  $p < .001$ ). In turn, action planning ( $b_1$  path,  $b = 0.11$ , 95CI = [0.08; 0.14],  $p < .001$ ) and self-monitoring ( $b_2$  path,  $b = 0.22$ , 95CI = [0.19; 0.26],  $p < .001$ ) were associated with physical activity. Moreover, intention remained positively associated with physical activity ( $c'_{1,2}$  path, direct effect,  $b = 0.23$ , 95CI = [0.20; 0.27],  $p < .001$ ). These results suggested that the association between intention and physical activity was (partly) mediated by action planning ( $c_1$  path, total effect,  $b = 0.29$ , 95CI = [0.25; 0.32],  $p < .001$ ) and by self-monitoring ( $c_2$  path, total effect,  $b = 0.33$ , 95CI = [0.29; 0.37],  $p < .001$ ).

Perceived energy was positively associated action planning ( $a_3$  path,  $b = 0.43$ , 95CI = [0.39; 0.48],  $p < .001$ ) and self-monitoring ( $a_4$  path,  $b = 0.50$ , 95CI = [0.44; 0.55],  $p < .001$ ), which were in turn associated with physical activity (paths  $b_3$  and  $b_4$ , respectively corresponding to abovementioned  $b_1$  and  $b_2$  paths). Perceived energy remained also positively associated with physical activity ( $c'_{3,4}$  path, direct effect,  $b = 0.08$ , 95CI = [0.05; 0.10],  $p < .001$ ). These results suggested that the effect of perceived energy on physical activity was (partly) mediated by

action planning ( $c_3$  path, total effect,  $b = 0.12$ ,  $95\text{CI} = [0.09; 0.15]$ ,  $p < .001$ ) and by self-monitoring ( $c_4$  path, total effect,  $b = 0.19$ ,  $95\text{CI} = [0.15; 0.22]$ ,  $p < .001$ ).

Finally, when investigating whether some path coefficients differed across countries, multigroup analysis showed that the fully unconstrained model (all paths being released across countries) provided a significantly better comparative fit to the data than the abovementioned constrained model, based on the  $\Delta\text{AIC} = 307$  and the  $\Delta\chi^2 = 434$  ( $p < .001$ ) (Table 4). However, the  $\Delta\text{BIC}$  favored the constrained model over the unconstrained model ( $\Delta\text{BIC} = -277$ ) – a common discrepancy between information criteria estimates in datasets with missing data (Lai, 2021). Based on the two first estimates, we decided to examine which paths differed across country by sequentially releasing each of them. Each released path provided a better comparative fit to the data, based on  $\Delta\text{AIC}$  and  $\Delta\chi^2$ . Results from a fully unconstrained model are reported by country in Table S2 and unstandardized  $b$  coefficients are displayed in Figures S1 and S2. This unconstrained model showed acceptable good fit to the data ( $\text{CFI} = .926$ ,  $\text{RMSEA} = .049$ ). Observed relationships were overall consistent across countries, although some differences in the significance and the weight of the paths was observed. First, the association between friends' support and intention was only significant among the Greek, Turkish and British samples. Second, the relationship of PBC with intention and of attitudes with intention were respectively weaker and stronger among the United Kingdom sample, relative to other countries.

### Sensitivity analyses

In the sample only composed of participants having fully completed the questionnaire ( $N = 7648$ ), we followed the same steps until achieving partial invariance and an acceptable model fit ( $\text{CFI} = .93$ ,  $\text{RMSEA} = .048$ ). Results from this constrained model were consistent with those observed in the main analyses and are reported in Table S3. Results from the model

adjusting for students' school were consistent with those observed in the main analyses (Table S4).

## Discussion

### Main findings

This large-scale study conducted in seven European countries extends our understanding of mechanisms underlying adolescents' physical activity in at least two ways. First, we showed that action planning and self-monitoring are mechanisms that (partly) explain how intention is translated into behaviour. Second, we revealed that perceived energy was positively associated with action planning and self-monitoring, suggesting that perceiving sufficient energy may represent an important driver in the development of self-regulation strategies among adolescents.

### Comparison with previous studies

As expected (H1), and consistent with the assumptions of the theory of planned behaviour (Ajzen, 1991), our results support the role of attitudes, PBC, family and friends' support in shaping adolescents' intention to be physically active. As already evidenced (Hagger et al., 2002), PBC had the strongest association with intention, with a large effect size, suggesting that fostering adolescents' beliefs in their own abilities and control is crucial in influencing their willingness to engage in physical activity. Family support and attitudes were also both associated with adolescents' intention to be active, confirming previous evidence (Hagger et al., 2002). We also found that the association of friends' support with intention was the smallest in term of weight in the constrained model, as already observed by previous research (Hamilton & White, 2008). Moreover, multigroup analyses showed that, in an unconstrained model, this path was significant among only three out of seven countries (i.e., Greece, Turkey and the United Kingdom), further suggesting that the association of friends' support with intention was of weaker importance. While several methodological features (e.g.,

items referring to “practical” social support, rather than to emotional social support, unspecificity of the items capturing intention in terms of context [structured vs unplanned physical activity]) can explain this inconsistency, the association between friends’ support and physical activity among youth seems to deserve further investigation (e.g., Hamilton et al., 2017).

Regarding other cross-cultural differences in these associations, we mostly observed that the association of PBC and attitudes with intention differed from the United Kingdom sample to adolescents from other countries. However, this finding should be interpreted with caution regarding the relatively small sample from the United Kingdom, as well as the achievement of a partially invariant measurement model across countries. Moreover, it also seems that adolescents from the United Kingdom reported more neutral attitudes toward physical activity and a weaker PBC, which could also explain these differences (Table 3, left-skewed distributions in Figure S3). Altogether, in order to strengthen adolescents’ intention to be physically active, these results reinforce the need to nurture supportive environments in which adolescents feel supported, especially by their family, and in which they develop favorable beliefs, high perceptions of control and ability toward PA, through repeated positive experiences. Additionally, in line with our hypothesis (H2), PBC emerged as a direct predictor of physical activity, further highlighting the key role of this variable in favoring a physically active lifestyle among adolescents.

Following our predictions (H3), both action planning and self-monitoring (partly) mediated the association between intention and physical activity. While previous studies provided scarce and inconsistent evidence on this relationship, our findings support the idea that these two self-regulation strategies may underlie the link between intention and action. Often considered in isolation from each other (see Nurmi et al., 2016 for an exception), action planning and self-monitoring yet refer to two different phases of the self-regulation processes.

While action planning is prospective and is assumed to favor the translation of intention into action by triggering an automatic mode of behavioural regulation as a response to encountered cues (Gollwitzer & Sheeran, 2006), self-monitoring constitutes a concurrent or retrospective strategy through which individuals estimate the degree of completion of their current goal, before reducing this potential discrepancy by forming new action plans (Carver & Scheier, 1982). In our study, these two strategies were both related to physical activity, thereby highlighting their independent predictive value. However, it has to be noted that intention remained directly associated with physical activity, supporting a partial mediating effect of action planning and self-monitoring. Other mechanisms, potentially related to self-regulation processes (e.g., coping planning, awareness of standards and self-regulatory effort) (Schwarzer & Luszczynska, 2008), may also further explain the relationship between intention and action. In light of these findings, we consider that developing a “self-regulation toolbox” among adolescents may represent an important target for future interventions aiming to promote physical activity. From that perspective, smartphone applications appear as a promising tool, assuming that adolescents are taught on how to use these technological devices. Physical Education teachers are also uniquely placed to help adolescents developing these skills (Maltagliati et al., 2021).

Finally, as hypothesized (H4), we evidenced, for the first time, that perceived energy was associated with physical activity through action planning and self-monitoring. As proposed by recent theoretical models (Forestier et al., 2022), these results suggest that self-regulatory resources may drive the development of self-regulation strategies. Indeed, developing action plans and self-monitoring is assumed to rely upon deliberative and effortful processes and would thus depend upon available resources (Hagger & Luszczynska, 2014). All so the more as developing these self-regulation strategies may be particularly taxing for some adolescents who report difficulties in planning their physical activity behaviours and in estimating their

physical activity levels (Renko et al., 2022). These findings also align with previous research demonstrating a link between perceived energy and physical activity (Cheval et al., 2021; Dunton et al., 2014; Hevel et al., 2021). However, our study complements them by further revealing that action planning and self-monitoring may underlie this association.

### **Strengths and limitations**

Among the strengths of this study are its large cross-cultural sample, the consistency of results across robustness analyses and its statistical approach combining measurement invariance, structural equation modeling and multigroup analyses. In particular, achieving partial invariance was a requisite for comparisons across countries to be made (Milfont & Fischer, 2010). Still, our analyses showed partial scalar invariance at the intercept level, with 17 of 39 intercepts having to be released across groups. This non-invariance of intercepts may be an indicator of potential measurement biases and suggests there may be cultural differences influencing how participants respond to these items (Putnick & Bornstein, 2016). Future studies using these scales should be conducted to examine the source of (scalar) invariance. However, some limitations also deserve to be acknowledged. First, the cross-sectional design of this study prevents us to infer causality between hypothesized associations and is likely to inflate the magnitude of observed associations. Second, despite the reliance on a composite score that was validated against an accelerometer-based measure, physical activity was self-reported, which may have led to inaccuracies, especially given adolescents' difficulties to estimate their own physical activity level. Third, though theoretically and empirically supported, the automatic mode of regulation through which action planning and self-monitoring may trigger physical activity was not examined in the present study. Future studies could aim to examine whether automaticity drives the association between these self-regulation strategies and daily-life physical activity, as observed among adults (Maltagliati et al., 2022). Finally, the relationship of perceived energy with physical activity through action planning and self-monitoring deserves

further investigation, regarding the potential bidirectional associations between these variables (i.e., perceived energy may positively influence physical activity, and vice versa). Particularly, ecological momentary assessment could provide a finer-grained perspective on the role of perceived energy in self-regulation processes.

### **Conclusion**

This study highlights that, beyond motivational antecedents of intention (i.e., attitudes, PBC, social support), developing action planning and self-monitoring among adolescents seems important as these self-regulatory strategies may both underlie the association between intention and action. All so the more as these self-regulatory strategies stand as potential low-cost and time-efficient targets for interventional studies among adolescents. Developing these skills may however not be straightforward among youth, as we revealed that action planning and self-regulation may be driven by the perception of one's energy. Accordingly, we encourage future studies to investigate the role of self-regulation strategies on the relationship between adolescents' intention to be physically active and actual behaviours, as well to explore the antecedents that may favor or impede the development of this self-regulation toolbox.



**Footnotes**

<sup>1</sup>: In this article, we will refer to action planning and this term will be considered as equivalent to implementation intention. These two terms have often been used interchangeably in previous research, though their conceptual distinction was previously established (Hagger & Luszczynska, 2014)

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**Competing interests**

The authors declare no competing interests.

**Data availability statement**

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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## Tables

**Table 1.** Demographic information for the full sample and by country.

	Full sample	France	Greece	Italy	Portugal	Spain	Turkey	United Kingdom
<b>N</b>	13136	1181	3031	2531	1003	1333	3371	686
<b>Age (mean, SD)</b>	13.8 (2.0)	13.1 (1.1)	12.9 (2.0)	14.6 (2.1)	14.5 (1.8)	14.5 (1.3)	13.9 (2.0)	13.3 (1.3)
<b>Gender</b>								
Female (n, %)	6812 (52%)	624 (53%)	1555 (51%)	1383 (55%)	550 (55%)	672 (50%)	1704 (51%)	324 (47%)
Male (n, %)	6284 (48%)	550 (47%)	1469 (48%)	1141 (45%)	453 (45%)	653 (49%)	1666 (49%)	352 (53%)
Non-binary (n, %)	40 (0%)	7 (1%)	7 (0%)	7 (0%)	0 (0%)	8 (1%)	1 (0%)	10 (1%)

*Note.* SD: Standard-deviation.

**Table 2.** Descriptive statistics and correlations between latent variables.

Variables	N	$\alpha$	Mean (SD)	Range	1	2	3	4	5	6	7	8	9
<b>1 – Attitudes</b>	12175	.91	5.62 (1.48)	1; 7	–								
<b>2 – Family support</b>	12090	.77	3.21 (.98)	1; 5	.32	–							
<b>3 – Friends' support</b>	12112	.79	3.08 (.99)	1; 5	.28	.47	–						
<b>4 – PBC</b>	11923	.85	4.83 (1.70)	1;7	.63	.39	.34	–					
<b>5 – Intention</b>	11895	.93	4.47 (1.92)	1; 7	.56	.39	.33	.68	–				
<b>6 – Action planning</b>	12178	.91	3.35 (1.15)	1; 5	.47	.50	.47	.55	.55	–			
<b>7 – Self-monitoring</b>	12125	.90	3.24 (1.15)	1; 5	.46	.50	.45	.55	.56	.73	–		
<b>8 – Perceived energy</b>	12202	.89	3.61 (.92)	1; 5	.34	.40	.39	.38	.34	.43	.46	–	
<b>9 – Physical activity</b>	9435	–	0 (1)	-2.05; 2.27	.40	.45	.42	.54	.58	.57	.58	.36	–

*Note.* PBC: Perceived behavioural control;  $\alpha$ : Cronbach alpha; SD: Standard-deviation; All relationships were significant with  $p < .001$ . Physical activity corresponds to the standardized latent variable combining the different items measuring physical activity.

**Table 3.** Descriptive statistics by country.

	France N = 1181		Italy N = 2531		Greece N = 3031		Portugal N = 1003		Spain N = 1333		Turkey N = 3371		UK N = 686	
Variables	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)
Attitudes	1056	5.75 (1.21)	2867	6.13 (1.02)	2374	5.68 (1.51)	984	5.61 (1.33)	1281	5.95 (1.29)	3024	5.04 (1.78)	589	4.91 (1.33)
Family support	1045	3.56 (.90)	2786	3.82 (.82)	2410	3.51 (.88)	1003	3.52 (.87)	1251	3.57 (.83)	3023	3.64 (1.04)	572	3.25 (.95)
Friends' support	1036	2.75 (.98)	2810	3.31 (.92)	2403	3.00 (.99)	1003	2.79 (.97)	1253	2.98 (.99)	3032	3.17 (.99)	575	3.01 (1.00)
PBC	1008	4.90 (1.67)	2753	5.18 (1.56)	2350	4.86 (1.73)	1003	4.75 (1.49)	1247	5.15 (1.53)	3000	4.41 (1.86)	562	4.61 (1.58)
Intention	1026	4.49 (1.98)	2816	4.91 (1.83)	2347	4.52 (1.96)	1003	4.44 (1.66)	1213	4.78 (1.88)	2908	3.92 (1.93)	582	4.13 (1.76)
Action planning	1010	3.40 (1.12)	2816	3.75 (1.00)	2400	3.75 (1.20)	1003	3.09 (1.05)	1274	3.37 (1.16)	3083	3.20 (1.18)	592	3.08 (1.08)
Self-monitoring	1003	3.15 (1.21)	2835	3.70 (1.00)	2391	3.08 (1.22)	1003	3.02 (1.09)	1263	3.17 (3.11)	3045	3.11 (1.11)	585	2.92 (1.08)
Perceived energy	1051	3.56 (.90)	2802	3.82 (.82)	2397	3.51 (.88)	1003	3.52 (.87)	1275	3.57 (.83)	3097	3.64 (1.04)	577	3.25 (.95)
Physical activity	1085	-.01 (.96)	1657	.26 (1.00)	1703	-.07 (.98)	1003	-.48 (.83)	1245	.18 (.96)	2179	-.06 (1.03)	563	.15 (1.01)

*Note.* UK: United Kingdom; SD: Standard-deviations; PBC: Perceived behavioural control. Physical activity corresponds to the standardized latent variable combining the different items measuring physical activity. The number of respondents who provided complete answers is reported for each variable and by country.

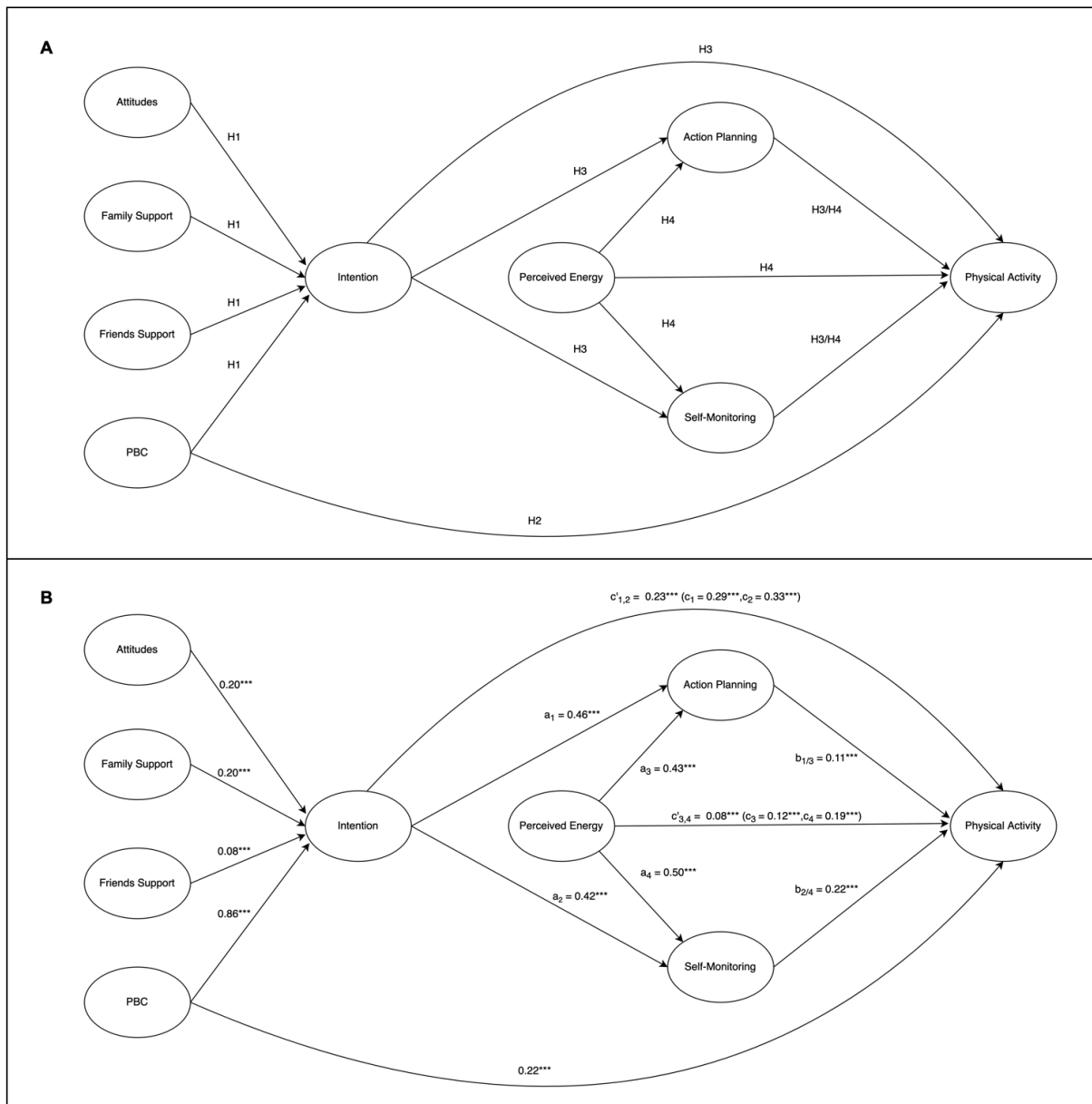
**Table 4.** Fit indices for the different cross-country invariance models in confirmatory factorial analyses and for the models including regression paths.

	$\chi^2$	df	CFI	RMSEA	BIC	AIC
<b><i>Cross-country invariance models</i></b>						
Configural	20918	4662	.946	.043	1075602	1067588
Metric	22893	4842	.940	.044	1075871	1069204
Scalar	31692	5022	.912	.053	1082965	1077645
Partially-invariant model	24088	4896	.937	.046	1077242	1071114
<b><i>Structural models</i></b>						
Constrained model	27981	5076	.924	.049	1078740	1073824
Unconstrained model	27547	4998	.926	.049	1079047	1073547

*Note.*  $\chi^2$ : Chi-squares; df: Degrees of freedom; CFI: Comparative fit indexes; RMSEA: Root mean square errors of approximation; BIC: Bayesian information criterion; AIC: Akaike information criterion. In the partially-invariant model, 17 intercepts were released, so that they were allowed to vary across countries.

### Figures

**Figure 1.** Hypothesized model (A) and results from the latent structural model (B)



*Note.* PBC: Perceived behavioural control. The model showed acceptable fit to the data (CFI = .92, RMSEA = .049). Unstandardized beta coefficients (b) are displayed. a: effect of the independent variable on the mediator; b: effect of the mediator on the dependent variable; c': direct effect, c: total effect; \*\*\*:  $p < .001$ . To improve the clarity of the figure, specification of latent variables by indicators is not displayed.