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

For correspondence:
silvio.maltagliat@univ-grenoble-alpes.fr
philippe.sarrazin@univ-grenoble-alpes.fr

Silvio Maltagliati[1], Athanasios Papaioannou[2], Damien Tessier[1], Attilio Carraro[3], Joan Pons[4], Gıyasettin Demirhan[5], Yago Ramis[6], Paul Appleton[7], Martins Joao[8], Géraldine Escriva-Boulley[9], Aïna Chalabaev[1], Boris Cheval[10,11], Charalambos Krommidas[2], Philippe Sarrazin[1]

[1] Univ. Grenoble Alpes, SENS, F-38000, Grenoble, France

[2] University of Thessaly, Department of Physical Education and Sport Science, Trikala, 42100, Greece

[3] Faculty of Education, Free University of Bozen-Bolzano, Viale Ratisbona 16, 39042 Brixen-Bressanone (BZ), Italy

[4] Department of Psychology, Universitat de les Illes Balears, Spain

[5] Hacettepe University, Faculty of Sports Sciences, Department of Physical Education and Sports Teaching, Ankara, 06800, Turkey

[6] Sport Research Institute/Departament de Psicologia Bàsica, Evolutiva i de l'Educació. Universitat Autònoma de Barcelona, Spain

[7] Department of Sport and Exercise Sciences, Manchester Metropolitan University, United Kingdom

[8] Faculdade de Motricidade Humana e UIDEF, Instituto da Educação, Universidade de Lisboa, Portugal

[9] LISEC UR2310, Université de Haute Alsace, Mulhouse, France & Université de Strasbourg, France & Université de Lorraine, France

[10] Swiss Center for Affective Sciences, University of Geneva, Geneva, Switzerland

[11] Laboratory for the Study of Emotion Elicitation and Expression (E3Lab), Department of Psychology, University of Geneva, Geneva, Switzerland

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Data availability statement

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

Competing interests

The authors declare no competing interests.

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 underlie 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 modelling showed that attitudes, PBC, family and friends' support) were all associated with intention (b*s.* > .08, *ps.* < .001). Intention (direct effect, b = .23, $p < .001$) and PBC were associated with PA (b = .22, $p < .001$). Action planning (indirect effect, b = .06, $p < .001$) and self-monitoring (indirect effect, b = .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 = .05, $p < .001$) and self-monitoring (indirect effect, b = .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 (Biddle et al., 2019; Granger et al., 2017; Lubans et al., 2016; 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; Hayes 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 (e.g., Michie & West, 2013).

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 (Brand & Cheval, 2019; Rhodes et al., 2019). Prominent among these motivational theories is the theory of planned behaviour (TPB) (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 offers 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 (Prochaska et al., 2002; Sallis et al., 2002). 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 TPB is that in turn 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 or adolescents (e.g., Downs & Hausenblas, 2005; 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 (Downs & Hausenblas, 2005; 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 TPB predicts greater variance in intention than in behaviours. For example, a meta-analysis revealed that a medium-to-large change in intention only resulted into a small-to-medium change in behaviour (Webb & Sheeran, 2006). Indeed, as more broadly observed (Sheeran, 2002), 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 meta-analyses consistently showing that the strength of the association between intention and behaviours was weaker among adolescents than among adults (Downs & Hausenblas, 2005; 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 (Fuchs et al., 2011; Schwarzer & Luszczynska, 2008). In particular, anchored within a self-regulation tradition (Carver & Scheier, 1982),

so-called hybrid models integrates post-decisional variables – here referred as self-regulation strategies – alongside with intention to explain the intention-action relationships (Fuchs et al., 2011; Schwarzer & Luszczynska, 2008)

Self-regulation strategies

Among these constructs, action planning[1] and self-monitoring have both shown promising beneficial effects on physical activity, especially when combined (Carraro & Gaudreau, 2013; 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; Baumeister & Vohs, 2007; Schwarzer, 2016). 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 me 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") (Carver & Scheier, 1982).

Because adolescents report difficulties in translating their intention to be active into intention into behaviours, they may especially particularly benefit from the use of these self-regulation strategies. However, despite their potential relevance and in spite 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 (Webb & Sheeran, 2007), 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 a goal-directed behaviour (e.g., playing football with my friends) (Gollwitzer & Sheeran, 2006; Sheeran et al., 2013). After this learning phase, behaviour is assumed to be rather automatically elicited (Maltagliati et al., 2022), as a response to encountering the related cues (Bayer et al., 2009). Yet, in the field of PA and among adolescents, some transversal studies reported positive associations between action planning and physical activity (Dombrowski & Luszczynska, 2009; Gerber et al., 2015; Roberts et al., 2010; Tessier et al., 2015), whereas non-significant associations were observed when intention was controlled for (Araujo-Soares et al., 2008; Gerber et al., 2011; Nurmi et al., 2016). Although a meta-analysis supported the positive association between action planning and physical activity among both adults and youth (Carraro & Gaudreau, 2013), 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.

As observed among adults (Michie et al., 2009), 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 news 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; Schofield et al., 2005). 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; Baumeister & Vohs, 2007; Schwarzer, 2016), 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

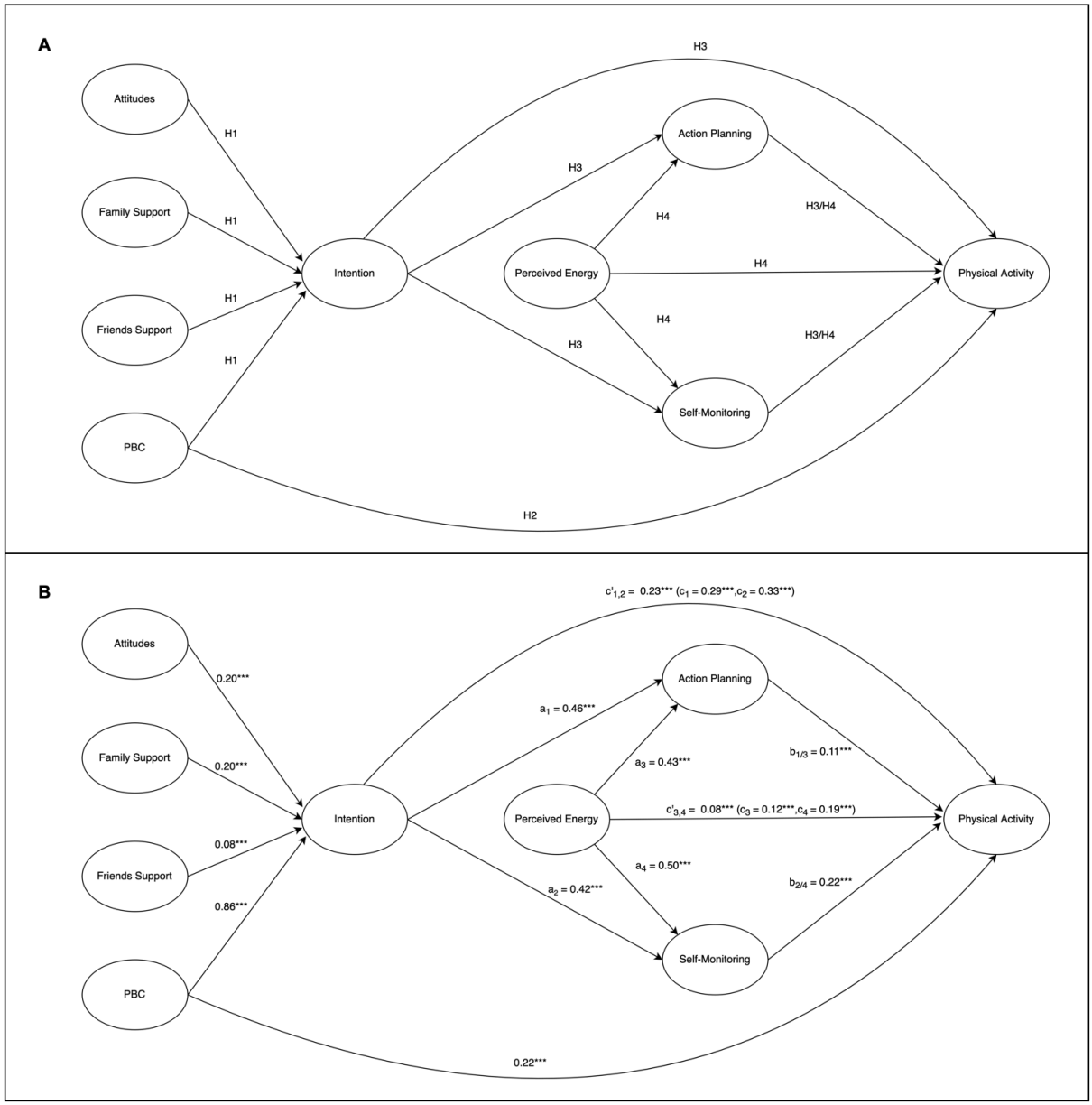
Yet, developing such self-regulation strategies may not be straightforward for adolescents who gradually need to learn to organize their physically active behaviours. In this perspective, another overlooked avenue of research concerns the factors which promote the development of action planning and self-monitoring. Stemming from the self-regulation literature (Forestier et al., 2022), one potential precursor involved in the development of these self-regulatory strategies is perceived energy (Forestier et al., 2018), corresponding to the perceived amount of energy available to the regulatory control of the one's self (Deci & Ryan, 2008; Ryan & Frederick, 1997). Indeed, developing self-regulatory strategies involve deliberative, reasoned and effortful processes (Hagger & Luszczynska, 2014; Wieber & Gollwitzer, 2017). 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 (Bagozzi et al., 2003), 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; Maher & Conroy, 2016), 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. As proposed by previous literature (Maher et al., 2019), 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 TPB, 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).

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



Note. 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

Methods

Procedure and participants

Data were collected within a European-wide project (link to website masked for review), whose background, aims and methods were extensively described elsewhere (Papaioannou et al., 2023). Briefly, adolescents from seven European countries (France, Greece, Italy, Portugal, Spain, Turkey and the United Kingdom) were invited to complete a questionnaire on their physical activity behaviours. They were offered the possibility to participate in this study by their respective Physical Education teacher, who was instructed on how to introduce the study, as well as on the study procedure. Questionnaires were completed using tablets or smartphones, during a Physical Education lesson and lasted about 30 minutes.

To participate in the study, participants had to be in middle school or in high school. In total, 13359 participants were included in the study. We included participants who provided minimal sociodemographics information (i.e., age, country, sex), resulting in a sample of 13136 participants (52% of female adolescents, mean age = 13.8 ± 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 provides 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 about 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 was measured using three items (Standage et al., 2003). Based on previous recommendations (Ajzen, 2002), 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 by 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 study from our research group by estimating its correlation with a concurrent accelerometer-based measure of physical activity in a subsample of Greek adolescents (Krommidas et al., 2023).

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 (ΔCFI) and RMSEA (ΔRMSEA) across models, with a ΔCFI ≤ .01 and ΔRMSEA ≤ .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. 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). In

this constrained model, paths coefficients were not allowed to vary across countries. 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.

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 paths were allowed to vary across samples) 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 on R (version 4.4), with the lavaan package (Rosseel, 2012).

Robustness analysis

We conducted a robustness analysis in which we only included participants who had fully completed the questionnaire (N = 7648), resulting in a drop of 5488 participants, relatively to main analyses.

Results

Descriptive statistics and bivariate correlations are reported for the overall sample in Table 2 and by country in Table 3.

Regarding measurement invariance (Table S1), configural invariance was supported with CFI = .946 and RMSEA = .043. When constraining factor loadings across samples, metric invariance was also supported, with ΔCFI = .006, ΔRMSEA = -.001. However, when constraining intercepts across samples, scalar invariance was not supported, with ΔCFI = .034 and ΔRMSEA = -.01. As planned, we sequentially released intercepts across countries, until achieving a ΔCFI < .01 and a ΔRMSEA ≤ .015. After sequentially releasing 17 intercepts on the 39 possible, corresponding to an acceptable ratio (Putnick &

Bornstein, 2016), we achieved a partially invariant model (ΔCFI = .010 and ΔRMSEA = -.003), which was retained as our measurement model in subsequent analyses.

When entering paths between latent variables, the model showed acceptable fit to the data (CFI = .92, RMSEA = .049) (Figure 1B). Regarding H1, 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.

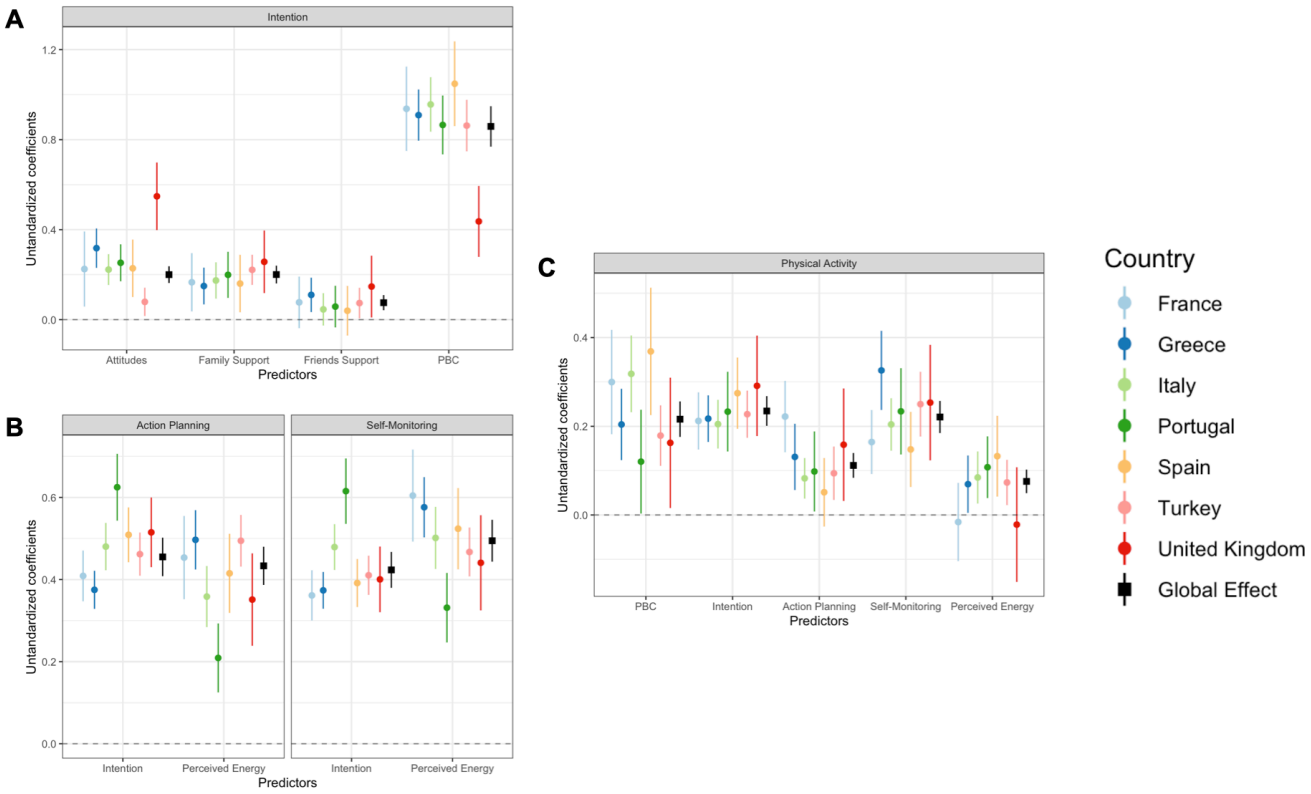
Regarding H2, PBC (b = 0.22, 95CI = [0.18; 0.26], $p < .001$), was positively associated with physical activity. Intention was positively associated with action planning (a_1 path, b = 0.46, 95CI = [0.41; 0.50], $p < .001$) and with self-monitoring (a_2 path, b = 0.42, 95CI = [0.38; 0.47], $p < .001$). 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 also 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, 95CI = [0.09; 0.15], $p < .001$) and by self-monitoring (c_4 path, total effect, b = 0.19, 95CI = [0.15; 0.22], $p < .001$).

Finally, when investigating whether some path coefficients differed across countries, multigroup analysis showed that the unconstrained model provided a significantly better comparative fit to the data than the constrained model, based on the ΔAIC = 306 and the $\Delta\chi^2 = 433$ ($p < .001$). However, the ΔBIC

favored the constrained model over the unconstrained model (ΔBIC = -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 ΔAIC and $\Delta\chi^2$. Results from a fully unconstrained model are reported by country in Table S2 and unstandardized b coefficients are displayed in Figure 2. Observed relationships were overall consistent across countries, although some differences in the significance and the weight of the paths could be 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. To provide effect sizes of these associations, standardized beta coefficients (β) and explained variance (R^2) are also reported by country in Table S2.

Figure 2. Paths coefficients by country from the unconstrained model, with intention (A), action planning (B), self-monitoring (B) and physical activity (C) being used as dependent variables.



Note. Unstandardized beta coefficients and their 95% confidence interval are displayed. Unstandardized coefficients from the constrained model are also reported as a reference point.

Robustness 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 (CFI = .93, RMSEA = .048). Results from this constrained model were consistent with those observed in the main analyses and are reported in Table S3.

Discussion

Main findings

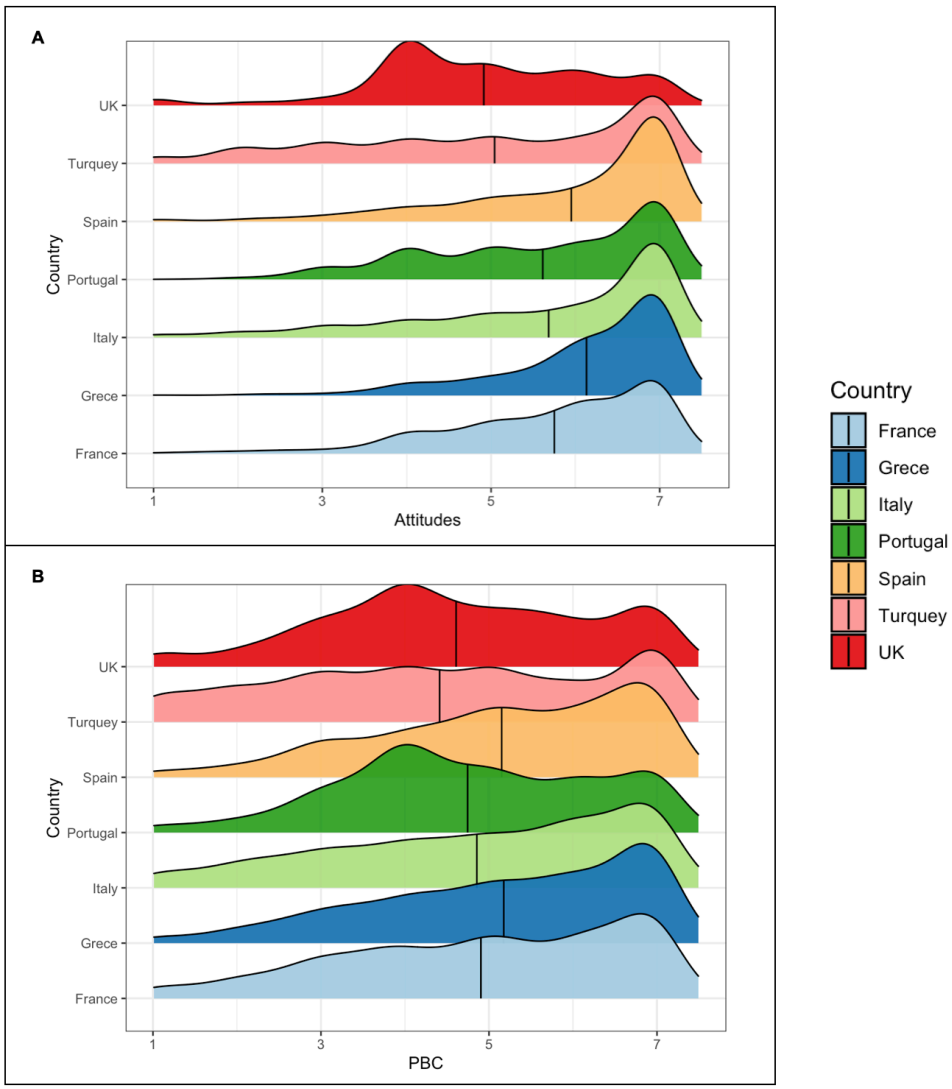
This large-scale study conducted in seven European countries extents our understanding of mechanisms underlying adolescents' physical activity in at least two ways. First, we showed that action planning and self-monitoring are mechanisms that (partly) explain how intention is translated into behaviour. 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 TPB (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 (Downs & Hausenblas, 2005; 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 (Downs & Hausenblas, 2005; 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 (left-skewed distributions in Figure 3, Table 3). 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.

Figure 3. Density plots of attitude and perceived behavioural control, by country.



Note. PBC: Perceived behavioural control. UK: United Kingdom. The vertical bar represents the mean by country.

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; Sheeran et al., 2013), 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. Further, we consider that developing a "self-regulation toolbox" among adolescents may represent an important target for future interventions aiming to promote physical activity among youth (Hynynen et al., 2016). Smartphone apps appear as a promising tool (Petersen et al., 2020), assuming that adolescents are taught on how to use these technological devices in order to convert their intention to be active into action. In that perspective, Physical Education teachers are uniquely placed to help adolescents developing these skills (Gobbi et al., 2020; Maltagliati et al., 2021). Still, 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.

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; Wieber & Gollwitzer, 2017). All so the more as developing these self-regulation strategies may be particularly taxing for some adolescents who report difficulties in planning their physically activity behaviours (Renko et al., 2022) and in estimating their physical activity levels (Mindell et al., 2014). These findings further 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; Maher & Conroy, 2016). 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 modelling and multigroup analyses. 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 (Mindell et al., 2014). Third, thought 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 (Maher et al., 2019)

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 own 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 (Hagger & Luszczynska, 2014) the development of this self-regulation toolbox.

Footnotes

[1]: In this article, we will refer to action planning and this term will be considered here as equivalent to implementation intention (Gollwitzer & Sheeran, 2006). These two terms have often been used interchangeably in previous research, thought their conceptual distinction was previously established (Hagger & Luszczynska, 2014).

Data availability statement

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

Competing interests

The authors declare no competing interests.

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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
N	13136	1181	3031	2531	1003	1333	3371	686
Age (mean, SD)	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)
Gender								
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	α	Mean (SD)	Range	1	2	3	4	5	6	7	8	9
1- Attitudes	12175	.91	5.62 (1.48)	1; 7	–								
2- Family support	12090	.77	3.21 (.98)	1; 5	.32	–							
3 – Friends' support	12112	.79	3.08 (.99)	1; 5	.28	.47	–						
4- PBC	11923	.85	4.83 (1.70)	1;7	.63	.39	.34	–					
5- Intention	11895	.93	4.47 (1.92)	1; 7	.56	.39	.33	.68	–				
6- Action planning	12178	.91	3.35 (1.15)	1; 5	.47	.50	.47	.55	.55	–			
7- Self-monitoring	12125	.90	3.24 (1.15)	1; 5	.46	.50	.45	.55	.56	.73	–		
8- Perceived energy	12202	.89	3.61 (.92)	1; 5	.34	.40	.39	.38	.34	.43	.46	–	
9- Physical activity	9435	–	0 (1)	-2.05; 2.27	.40	.45	.42	.54	.58	.57	.58	.36	–

Note. PBC: Perceived behavioural control; α: 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. Accordingly, its mean and standard-deviation are equal to 0 and 1, respectively.

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. Physical activity corresponds to the standardized latent variable combining the different items measuring physical activity. Accordingly, its mean and standard-deviation are equal to 0 and 1, respectively. The number of respondents who provided complete answers is reported for each variable and by country.

Supplementary material

Table S1. Fit indices for the different cross-country invariance models in confirmatory factorial analyses and for the models including regression paths.

Table S2. Results from the unconstrained model, by country.

Table S3. Results from robustness analyses including only participants who fully completed the questionnaire (N = 7648).

Table S1. Fit indices for the different cross-country invariance models in confirmatory factorial analyses and for the models including regression paths.

	χ^2	df	CFI	RMSEA
Cross-country invariance models				
Configural	20918	4662	.946	.043
Metric	22893	4842	.940	.044
Scalar	31692	5022	.912	.053
Partially-invariant model	24088	4896	.937	.046
Models including regression paths				
Constrained model	27981	5076	.924	.049
Unconstrained model	27547	4998	.926	.049

Note. χ^2: Chi-squares; df: degrees of freedom; CFI: comparative fit indexes; RMSEA: root mean square errors of approximation. In the partially-invariant model, 17 intercepts were released, so that they were allowed to vary across countries.

Table S2. Results from the unconstrained model, by country.

	France				Greece				Italy				Portugal			
Predictors	**b**	**95CI**	***p***	**β**	**b**	**95CI**	***p***	**β**	**b**	**95CI**	**p**	**β**	**b**	**95CI**	***p***	**β**
Dependent variable: intention																
Attitudes	.23	.06; .39	.008	.12	.32	.23; .41	< .001	.16	.22	.15; .29	< .001	.15	.25	.17; .33	< .001	.19
Family support	.17	.04; .30	.012	.09	.15	.07; .23	< .001	.08	.17	.09; .25	< .001	.10	.20	.10; .30	< .001	.14
Friends' support	.08	-.04; .19	.188	.04	.11	.03; .19	.005	.06	.05	-.03; .12	.212	.03	.06	-.03; .15	.218	.04
PBC	.94	.75; 1.12	< .001	.58	.91	.80; 1.02	< .001	.58	.96	.84; 1.08	< .001	.63	.87	.73; 1.00	< .001	.60
R^2		.57				.57				.66				.71		
Dependent variable: Action planning																
Intention	.41	.35; .47	< .001	.49	.37	.33; .42	< .001	.46	.48	.42; .54	< .001	.51	.62	.54; .71	< .001	.65
Perceived energy	.45	.35; .55	< .001	.30	.50	.42; .57	< .001	.33	.36	.28; .43	< .001	.21	.21	.13; .29	< .001	.15
R^2		.46				.43				.38				.53		
Dependent variable: Self-monitoring																
Intention	.36	.30; .42	< .001	.41	.37	.33; .42	< .001	.47	.48	.42; .53	< .001	.54	.62	.54; .69	< .001	.63
Perceived energy	.60	.49; .72	< .001	.38	.58	.50; .65	< .001	.39	.50	.43; .58	< .001	.30	.33	.25; .42	< .001	.23
R^2		.45				.51				.50				.58		
Dependent variable: Physical activity																
Intention	.21	.15; .28	< .001	.28	.22	.16; .27	< .001	.25	.20	.15; .26	< .001	.25	.23	.14; .32	< .001	.30
PBC	.30	.18; .42	< .001	.24	.20	.12; .28	< .001	.15	.32	.23; .40	< .001	.26	.12	.00; .24	.044	.11
Action planning	.22	.14; .30	< .001	.24	.13	.06; .21	.001	.12	.08	.04; .13	< .001	.10	.10	.01; .19	.033	.12
Self-monitoring	.16	.09; .24	< .001	.19	.33	.24; .42	< .001	.29	.20	.15; .26	< .001	.22	.23	.14; .33	< .001	.30
Perceived energy	-.02	-.10; .07	.723	-.01	.07	.00; .13	.035	.04	.08	.03; .14	.005	.06	.11	.04; .18	.002	.09
R^2		.63				.51				.56				.65		

Table S2. (Following)

	Spain				Turkey				United Kingdom			
Predictors	**b**	**95CI**	***p***	**β**	**b**	**95CI**	***p***	**β**	**b**	**95CI**	***p***	**β**
Dependent variable: intention												
Attitudes	.23	.10; .36	< .001	.14	.08	.02; .14	.013	.06	.55	.40; .70	< .001	.37
Family support	.16	.03; .29	.014	.09	.22	.15; .29	< .001	.14	.26	.12; .40	< .001	.17
Friends' support	.04	-.07; .15	.481	.02	.07	.01; .14	.033	.04	.15	.01; .28	.035	.10
PBC	1.05	.86; 1.24	< .001	.61	.86	.75; .98	< .001	.63	.44	.28; .59	< .001	.29
R^2		.60				.60				.65		
Dependent variable: Action planning												
Intention	.51	.44; .58	< .001	.55	.46	.41; .51	< .001	.50	.51	.43; .60	< .001	.55
Perceived energy	.42	.32; .51	< .001	.24	.49	.43; .56	< .001	.35	.35	.24; .46	< .001	.25
R^2		.45				.52				.49		
Dependent variable: Self-monitoring												
Intention	.39	.33; .45	< .001	.46	.41	.36; .46	< .001	.49	.40	.32; .48	< .001	.45
Perceived energy	.52	.43; .62	< .001	.33	.47	.41; .53	< .001	.37	.44	.32; .56	< .001	.33
R^2		.42				.52				.44		
Dependent variable: Physical activity												
Intention	.27	.19; .35	< .001	.32	.23	.17; .28	< .001	.27	.29	.18; .40	< .001	.31
PBC	.37	.23; .51	< .001	.25	.18	.11; .25	< .001	.16	.16	.02; .31	.030	.12
Action planning	.05	-.03; .13	.194	.06	.09	.03; .15	.002	.10	.16	.03; .29	.014	.16
Self-monitoring	.15	.06; .23	.001	.15	.25	.18; .32	< .001	.25	.25	.12; .38	< .001	.24
Perceived energy	.13	.04; .22	.004	.08	.07	.02; .12	.005	.06	-.02	-.15; .11	.741	-.02
R^2		.52				.51				.49		

Note. Unstandardized beta coefficients (b), their 95% confidence interval (95CI), *p*-values and standardized coefficients (β) are reported. Explained variance (R^2) is also reported by country.

Table S3. Results from robustness analyses including only participants who fully completed the questionnaire (N = 7648).

Predictors	b (95CI)	*p*
Dependent variable: Intention		
Attitudes	.25 (.20; .29)	< .001
Family support	.23 (.19; .28)	< .001
Friends' support	.05 (.01;.08)	.030
PBC	.81 (.71; .91)	< .001
Dependent variable: Action planning		
Intention	.49 (.43; .55)	< .001
Perceived energy	.42 (.36; .47)	< .001
Dependent variable: Self-monitoring		
Intention	.48 (.42; .54)	< .001
Perceived energy	.52 (.46; .59)	< .001
Dependent variable: Physical activity		
Intention	.25 (.20; .29)	< .001
PBC	.22 (.17; .27)	< .001
Action planning	.14 (.10; .18)	< .001
Self-monitoring	. 22 (.18; .23)	< .001
Perceived energy	.07 (.04; .10)	< .001

Note. Unstandardized beta coefficients, their 95% confidence interval, and *p*-values are reported. The model showed acceptable fit to the data (CFI = .93, RMSEA = .048).