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Uncovering the roles of automatic attitudes and controlled processes in the regulation of physical activity behavior in children

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A R T I C L E I N F O

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A B S T R A C T

Despite substantial research efforts to increase engagement in physical activity (PA), children are not sufficiently active. Dual-process theories suggest that PA behavior regulation occurs through both controlled (i.e., reflective, conscious) and automatic (i.e., non-reflective, less conscious) processes. Automatic processes depend on affective valuations and attitudes towards PA and have been shown to predict PA behavior. However, their role in PA behavior regulation in children remains unclear. Therefore, the current study investigated the unique association of automatic attitudes towards PA on self-reported seven-day PA recall, after accounting for the effects of known controlled precursors of PA (i.e., explicit attitudes, PA self-efficacy, and PA intentions). In a cross-sectional design, 69 children (age = 10.8 ± 0.6 years) completed the Single-Category Implicit Association Task (SC-IAT) and self-reported measures of PA and controlled precursors of PA. In a hierarchical regression analysis, controlled processes accounted for 28.3 % of the variance in PA behavior. Although the bivariate association between automatic attitudes and PA was not significant, the association between them became significant but negative in the fully adjusted model ($b = -1.70$; $p = 0.025$). The fully adjusted model accounted for 35.0 % of the variance in PA. In summary, the findings indicated that both controlled and automatic processes predicted PA in children, although the association with automatic attitudes was not in the expected direction in the adjusted model. Future studies are warranted to further understand the role of automatic processes in the regulation of PA behavior in children.

1. Introduction

The UK Chief Medical Officer and the World Health Organization (WHO) recommend children and adolescents to engage in at least of 60 min of moderate-to-vigorous physical activity (PA) per day, on average. However, around 50 % of children in the UK and around 81 % of adolescents globally do not meet the PA guidelines (Farooq et al., 2018; Griffiths et al., 2013; Guthold, Stevens, Riley, & Bull, 2020). Despite substantial efforts to promote PA in this population, it remains unclear why children do not engage in sufficient PA (Sallis et al., 2016). Most of the currently available PA research (based on social-cognitive theories) stems from the assumption that PA behavior regulation occurs through controlled processes that underpin reasoned motivation and intentions (e.g., educational interventions targeting PA knowledge; Gourlan et al., 2016; Rhodes & Rebar, 2017). Controlled processes are consciously accessible beliefs and attitudes that can be articulated (e.g., in self-report measures) and shape the deliberate intentions to engage in PA (Nosek, 2007; Rhodes & Rebar, 2017). Several of the dominant social-cognitive theories, including Social Cognitive Theory (Bandura, 2001) and Theory of Planned Behavior (Ajzen, 1991), consider PA intentions to be the modifiable factor that most closely influences PA and has been the target of many interventions (Rhodes & Rebar, 2017; Sheeran, Maki, et al., 2016a). In line with the social-cognitive theories, controlled processes, including affective and instrumental attitudes, and PA self-efficacy have been found to predict PA both directly and indirectly through PA intentions (Ajzen, 1991; Bandura, 2001; Sheeran, Maki, et al., 2016b).

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Although some factors based on several controlled processes (e.g., explicit attitudes, PA self-efficacy and PA intentions) have shown consistent positive associations with PA, evidence from PA interventions in children is mixed and has shown small or even negligible effects on PA in the long-term (Brown et al., 2016; Phipps et al., 2022; Sheeran, Maki, et al., 2016b). Recently, it was demonstrated that only half of adults who formed a PA intention ultimately engaged in PA, suggesting that the likelihood of PA engagement after the formation of PA intentions is close to chance (Feil, Fritsch, & Rhodes, 2023; Sheeran & Webb, 2016). Thus, in order to go beyond controlled processes, dual-process theories have proposed that PA behavior is also regulated by automatic (implicit) processes (Brand & Ekkekakis, 2018; Cheval & Boisgontier, 2021; Conroy & Berry, 2017; Schinkoeth & Antoniewicz, 2017). Automatic processes refer to cognitive, affective and motivational processes that are non-reflective, rapid and can influence behavior without the individual's intention or awareness (Conroy & Berry, 2017; Sheeran, Bosch, et al., 2016b). Automatic processes are triggered when individuals are presented with PA-related cues (external or internal) because they activate affective valuations of PA and automatic attractions to less energetically costly alternatives (Brand & Ekkekakis, 2018; Cheval & Boisgontier, 2021; Conroy & Berry, 2017). Such a distinction between controlled and automatic processes has been debated as they may not belong to two separate systems and a more nuanced view is warranted (Melnikoff & Bargh, 2018). However, the dichotomization posited in dual-process theories is a pragmatic one, which allows their assessment in experimental studies and integration into interventions (Cheval et al., 2018).

Affective valuations of PA are based on past PA experiences relating to affective responses (feelings of pleasure and displeasure) and/or emotional evaluations (of social and environmental factors) (Brand & Ekkekakis, 2018). Affective valuations and attractions form the basis for automatic attitudes, which are processes that influence the speed of recognition and direction of attention in the early stages of behavior planning (Cheval, Miller, et al., 2019; Conroy & Berry, 2017). Thus, automatic attitudes account for the affective valuation and automatic attraction to PA that are activated when individuals are presented with PA-related cues (Conroy & Berry, 2017). Automatic processes ultimately result in an impulse to either approach or avoid PA (Brand & Ekkekakis, 2018; Cheval & Boisgontier, 2021; Conroy & Berry, 2017). Other accounts have also suggested that the rewards associated with the PA (or sedentary behavior; SB), which could be in the form of affective responses, may mediate the associations between repeated situational cues and PA (Cheval, Boisgontier, Bacelar, Feiss, & Miller, 2019; Judah, Gardner, Kenward, DeStavola, & Aunger, 2018). Thus, forming a habit where impulses for action are triggered at the presentation of the cue (Gardner, Rebar, De Wit, & Lally, 2024). In contrast to controlled processes, the role of automatic processes in PA behavior regulation has received less attention, particularly in children. Children's cognitive development status may distinguish them from adults. As previously demonstrated, children's behavior is characteristically impulsive, suggesting that automatic processes play an important role in their PA behavior regulation (Tao, Wang, Fan, & Gao, 2014). As such, automatic attitudes form the basis of automatic processes and provide a good starting point for understanding the role of automatic processes in the regulation of PA behavior in children.

Studies measuring automatic attitudes towards PA in adults have shown that more positive (and stronger) attitudes are associated with higher levels of PA (Calitri, Lowe, Eves, & Bennett, 2009; Conroy, Hyde, Doerksen, & Ribeiro, 2010). For example, a systematic review and meta-analysis of 26 studies found an overall positive and significant association between automatic attitudes and PA (Chevance, Bernard, Chamberland, & Rebar, 2019). Additionally, studies measuring controlled processes and automatic attitudes have found that the two work synergistically in predicting PA (Cheval, Sarrazin, Isoard-Gautheur, Radel, & Friese, 2015; Conroy et al., 2010; Muschalik, Elfeddali, Candel, & de Vries, 2018). In children, automatic attitudes have been studied to understand health and social behaviors related to smoking (Andrews, Hampson, Greenwald, Gordon, & Widdop, 2011), eating behaviors (DeJesus, Gelman, & Lumeng, 2020) and racial attitudes (Baron & Banaji, 2006). To the best of our knowledge, only a few studies have investigated automatic attitudes towards PA in children (Craeynest et al., 2005; Limmeroth & Raboldt, 2022; Mücke, Ludyga, Andrä, Gerber, & Herrmann, 2021; Scotto Di Luzio et al., 2023). Two studies examined the differences in automatic attitudes towards healthy and unhealthy foods and PA and sedentary behavior between obese and non-obese children, and both found no differences in automatic attitudes between the groups (Craeynest et al., 2005; Scotto Di Luzio et al., 2023). However, there was no difference in PA levels between these groups in either study, which may explain the lack of difference. Furthermore, two studies found associations between automatic attitudes towards PA and device-measured PA (Limmeroth & Raboldt, 2022; Mücke et al., 2021). Specifically, Mücke et al. (2021) found an association between automatic attitudes and vigorous PA, but not moderate-to-vigorous PA. Additionally, Mücke et al. (2021) also found an association between automatic attitudes and basic motor competencies (i.e., the ability to perform basic movement skills; e.g., jumping or throwing) as an indicator of the ability to engage in PA (as a precursor to PA self-efficacy). Limmeroth and Raboldt (2022) found automatic attitudes to predict PA, explaining 11 % of the variance, but only for PA during weekdays and not for PA during weekends. As such, Limmeroth and Raboldt (2022) and Mücke et al. (2021) indicated that an association exists between automatic attitudes and PA in children, but may depend on timing and intensity of the PA. Previous studies investigated the direct associations between automatic attitudes and PA but did not investigate the contribution of automatic attitudes in addition to controlled processes, such as explicit attitudes, PA self-efficacy and PA intentions.

The aim of the current study was to investigate the unique association of automatic attitudes towards PA on self-reported seven-day PA recall, after accounting for the effects of known controlled precursors of PA (i.e., explicit attitudes, PA self-efficacy, and PA intentions). The current study employed a cross-sectional design where measures of automatic attitudes towards PA, controlled processes (explicit affective and instrumental attitudes towards PA, PA self-efficacy and PA intentions) and a seven-day PA recall were taken in a single session. Based on the tenets of social-cognitive theories (Ajzen, 1991; Bandura, 2001), it was hypothesized (H1) that controlled processes, including explicit affective and instrumental attitudes and PA self-efficacy, would be significantly associated with PA in children directly and that self-efficacy would also be significantly associated with PA through PA intentions. Based on the currently available theoretical and empirical evidence, it was also hypothesized (H2) that automatic processes (automatic attitudes) would be significantly associated with PA in children over and above the effects of controlled processes.

2. Method

2.1. Participants

Children in grades five and six were recruited through local primary schools with written permission from the school leaderships. Both parents and children were provided with information sheets describing the methods and procedures of the study and were asked to provide their consent to participate in the study. Informed consent was obtained from the parents and assent was obtained from the children. The parents were asked to complete a short questionnaire about their child regarding sex, date of birth, ethnic background, presence of clinically diagnosed mental health issues (e.g., ADHD) and presence of physical/intellectual disabilities which may influence PA behavior. The presence of clinically diagnosed mental health issues and presence of physical/intellectual disability were used as exclusion criteria. The required sample size was estimated using GPower 3.1 (Erdfelder, Faul, & Buchner, 1996). As no previous similar data was available for power analysis to the authors' knowledge, a moderate effect size was used. For a moderate effect size (f^2) of 0.15, a power of 80 % and an α error probability of 0.05, the required sample size for a multiple regression analysis with 5 total predictors was 77 (Selya, Rose, Dierker, Hedeker, & Mermelstein, 2012). To account for potential attrition and invalid data of about 10 %, we aimed to recruit 85 participants.

2.2. Procedures

Ethical approval was obtained from Northumbria University ethical review board (reference: 3416). In the current cross-sectional study, all measures were administered during a single session. Data were collected in a classroom setting with up to 15 participants in each session, with participants seated on individual desks approximately 2 m apart. The participants received an introduction to the procedures of the study. The concept of PA was defined in lay terms (based on the WHO definition; Bull et al., 2020) as *"physical activity is anything that involves the body moving, like walking, running, cycling, doing sports or playing around"*. Automatic attitudes were measured first, followed by self-reported measures in order: PA (7-day recall), PA self-efficacy, PA intentions, affective and instrumental attitudes. At the end of the session, participants' body height and mass were measured individually in an adjacent room.

2.3. Single-category implicit association task

Automatic attitudes reflect the automaticity of affective valuation of PA, making them difficult to measure using self-report measures (Conroy & Berry, 2017; Sheeran, Bosch, et al., 2016b). The Implicit Association Task (IAT) is a reaction-time-based task designed to test automatic attitudes (the strength and direction of mental associations) in relation to two opposing target stimuli (Greenwald, Nosek, & Banaji, 2003). On the other hand, Single-Category IAT (SC-IAT) focuses on one target stimulus (rather than two opposing targets) (Karpinski & Steinman, 2006). The SC-IAT allows for the measurement of absolute positive or negative attitudes towards one target (e.g., PA) rather than the relative attitudes between two targets (e.g., PA vs. sedentary activity; Karpinski & Steinman, 2006). Although the SC-IAT has been widely used to investigate automatic attitudes (Chevance et al., 2019), its psychometric properties in relation to PA have not been tested in children. One study in children Mücke et al. (2021) used the SC-IAT to measure automatic attitudes towards PA, but did not report measures of validity or reliability. Therefore, no data is available regarding the validity and reliability of the PA-specific SC-IAT in children. In adults, among nine measures of automatic attitudes, the SC-IAT showed low validity (Zenko & Ekkekakis, 2019b). Other studies have shown acceptable reliability of the SC-IAT in adults (α range = 0.63–0.83) (Hyde, Elavsky, Doerksen, & Conroy, 2012; Muschalik et al., 2018). Measures of automatic processes rely on reaction times to infer automaticity and the mechanisms they measure are often not fully understood, and therefore often show low reliability (Zenko & Ekkekakis, 2019a). The psychometric properties of the SC-IAT need exploration in children and the current study reported its reliability using the split-half reliability method.

The SC-IAT was hosted on Inquisit Web (*Inquisit Web*, 2023) and administered on an Apple iPad, which allowed multiple participants to complete the task simultaneously. The participants were given instructions for the SC-IAT and a preview of the stimuli, highlighting that the words were either positive or negative and the images depicted PA behavior. See Table 1 and Fig. 1 for a detailed description of the SC-IAT. The SC-IAT followed the design of Karpinski and Steinman (2006) with visual modification to suit a child population, including happy/sad faces, word selection and pictorial stimuli (Axt, Feng, & Bar-Anan, 2021; DeJesus et al., 2020; Mücke et al., 2021). The SC-IAT consisted of four blocks divided into two sets (positive and negative), with each set containing one practice block (omitted from the analysis) and one test block (used for analysis). In the positive and negative sets, the PA stimuli were associated with a happy and a sad face, respectively. The order of the sets was counterbalanced across participants. Images depicting a stick figure engaging in PA were used as PA stimuli. Two categories of words with positive and negative connotations were used. A happy face was located in the upper left corner of the screen and a sad face was located in the upper right corner of the screen, representing positive and negative attributes. The phrase "Physical activity" was displayed below the happy face during the positive set and below the sad face during the negative set.

Table 1
Design of the Single Category – Implicit Association Task. Positive (n = 15) and negative (n = 15) words used in SC-IAT. See Axt et al. (2021) for word selection.

Block #	n Trials	Block function	Left	Right
1	24	Practice	Happy face + Physical activity	Sad face
2	72	Test	Happy face + Physical activity	Sad face
		Positive words: Funny, Happy, Yummy, Smile, Pleasant, Beautiful, Helpful, Love, Cute, Comfortable, Friendly, Excellent, Best, Cool, Success		
3	24	Practice (reverse)	Happy face	Sad face + Physical activity
4	72	Test (reverse)	Happy face	Sad face + Physical activity
		Negative words: Boring, Sad, Yucky, Cry, Unpleasant, Horrible, Selfish, Hate, Disgusting, Nasty, Wrong, Worst, Terrible, Harmful, Fail		

The stimuli were displayed in the centre of the screen in random order. The participants were asked to press the "E" button for the left side and the "I" button for the right side to categorize the words to their corresponding attribute (positive or negative). Similarly, the participants were asked to press the "E" and "I" buttons to assign the stimuli to the side where words "Physical activity" were displayed. The participants were instructed to respond as quickly and accurately as possible. For each trial, the stimulus was presented until a response was registered and the interstimulus interval was 250 ms with a blank screen. For a correct response, the next trial started. For an incorrect response, an "X" appeared below the stimulus until a correct response was made. A reminder in yellow, "Try to go quicker", appeared on the screen after 2000 ms and remained for 500 ms if a response was too slow. Trials with responses faster than 300 ms or slower than 10,000 ms were excluded from analysis. Participants were excluded if their responses were faster than 300 ms on 10 % or more of the trials or incorrect on 20 % or more of trials (Andrews et al., 2011; Greenwald et al., 2003; Karpinski & Steinman, 2006). Mean and standard deviation (SD) were calculated for the reaction time of each of the two experimental blocks (i.e., 2 and 4). As shown in Equation 1 d-score was calculated by subtracting the mean reaction time on negative test trials from the mean reaction time on positive trials and dividing by the standard deviation of the reaction time across all correct trials (Greenwald et al., 2003; Karpinski & Steinman, 2006; Richetin, Costantini, Perugini, & Schönbrodt, 2015).

$$d = \frac{RT_P - RT_N}{SD_{POOLED}}, \text{ where } SD_{POOLED} = \sqrt{\frac{SD_P^2 + SD_N^2}{2}} \quad (1)$$

The d-score ranges from −2 to +2, with a positive d-score indicating a positive attitude and a negative d-score a negative attitude, and more extreme d-scores indicating stronger attitudes (Blanton, Jaccard, & Burrows, 2015; Karpinski & Steinman, 2006). Cut points for the d-score have been set to 0.15 indicating slight attitude, 0.35 moderate attitude and 0.65 strong attitude (Blanton et al., 2015). The split-half reliability was estimated using a random splitting method, yielding Pearson correlation coefficient adjusted using the Spearman-Brown Prophecy formula, comparable to Cronbach alpha (De Vet, Mokkink, Mosmuller, & Terwee, 2017; Parsons, 2021). The split-half reliability for the SC-IAT

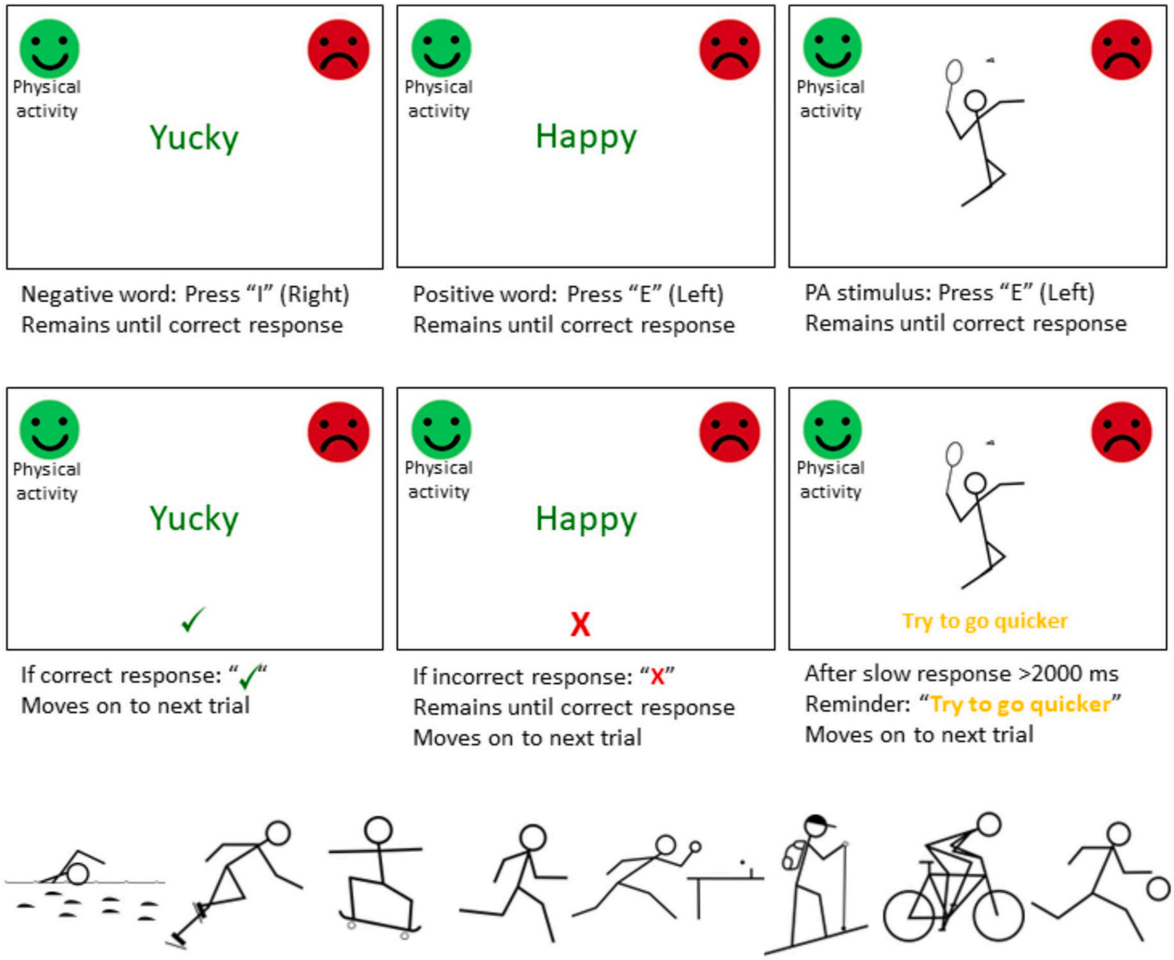

Fig. 1. Example screens of the SC-IAT and the eight PA stimuli used.

was estimated to be r = 0.68.

2.4. Physical activity behavior

The Youth Activity Profile (YAP; Saint-Maurice & Welk, 2015) was used to measure PA based on a recall of PA and sedentary behaviors in the past seven days. The YAP comprises three sections measuring PA at school (including physical education and breaks), outside of school (including structured exercise, play and active transport) and overall sedentary behaviors (including time spent sitting using devices), with five items in each section. Each item was scored on a five-option multiple choice (a score of 1–5), indicating time spent for each activity (e.g., No activity – 0 min; Large amount of activity – more than 2 h). Each section of the YAP was averaged separately and the averages for the activity sections (at school and outside of school) were summed to provide an overall score of PA, yielding a score of up to 10. The internal reliability coefficient for self-reported seven-day PA recall was estimated at α = 0.72.

2.5. Physical activity self-efficacy

A previously validated 8-item questionnaire was used to measure PA self-efficacy, which measures the confidence in one's ability to be physically active (Motl et al., 2000). The self-efficacy questionnaire statements (sample item: "I can be physically active during my free time on most days") and was scored on a 5-point Likert scale (1 = Strongly disagree, 5 = Strongly agree). An average score was calculated for the eight items. The internal reliability coefficient for PA self-efficacy was estimated at α = 0.68.

2.6. Physical activity intention

Physical activity intentions were measured as intention strength, specifically targeting the PA intentions. Intention strength is representative of deliberate intentions, that is, a deliberate motivation for a behavior as described in the current study as a controlled process (Rhodes & Rebar, 2017). Three items were used in a self-constructed questionnaire targeting three types of PA: organized physical activities, playing/recreational activities, and active transportation. The questionnaire items were formulated as intentions to engage in PA: "I intend to do participate in some sort of structured sport with an instructor/coach in the next 7 days (week)", "I intend to spend time playing with siblings or friends in the next 7 days (week)", "I intend to walk/cycle/scoot to school at least one day in the next 7 days (week)". The PA intentions items were scored on a 5-point Likert scale (1 = Strongly disagree, 5 = Strongly agree) and a sum score for the three items was calculated. Similar items to measure PA intention have been used in previous studies (Foley et al., 2008). The internal reliability coefficient for PA intentions was estimated at α = 0.60.

2.7. Explicit attitudes towards physical activity

Explicit attitudes were measured using four items on a 10-point semantic differential scale between two opposites. Two items measured explicit affective attitudes related to the feeling and enjoyment of PA: "feels good (pleasant)" vs. "feels bad (unpleasant)" and "fun (enjoyable)" vs. "boring (unenjoyable)". Two items measured explicit instrumental attitudes related to utility and importance of PA: "healthy (good for me)" vs. "unhealthy (bad for me)" and "important" vs. "unimportant". Average scores were calculated for affective and instrumental attitudes, respectively. As the scales for affective and instrumental attitudes only included two items each, the Spearman-Brown coefficient for the two-item scales was calculated as a measure of reliability, with $\rho = 0.88$ for affective attitudes and $\rho = 0.51$ for instrumental attitudes (Eisinga, Grotenhuis, & Pelzer, 2013).

2.8. Anthropometric measures

Height and body mass were measured individually at the end of the session in an adjacent room. Height was measured using a generic wall-mounted stadiometer, and body mass was measured using a digital scale (*Salter, n.d.*). Body mass index (BMI) was calculated using the formula BMI = body mass/$height^2$ and BMI z-scores (BMI-for-age) were calculated using the *zscorer* R package (Myatt & Guevarra, 2019), which is based on the WHO reference growth data for children and adolescents aged 5–19 years (De Onis et al., 2007).

2.9. Data analysis

Data analysis was performed in R (R Core Team, 2019) using the *lmtest* R package (Zeileis & Hothorn, 2002). Hierarchical multiple regression analysis was performed to test the associations between the controlled processes on PA. Explicit affective and instrumental attitudes, PA self-efficacy, PA intentions and automatic attitudes (d-score) were used as independent variables, Sex and BMI were used as control variables and PA was used as the dependent variable. First, in block 1, an initial test of the control variables Sex and BMI was conducted. Block 2 and block 3 of the hierarchical regression was used to test the first hypothesis, including PA self-efficacy, explicit affective attitudes and instrumental attitudes as independent variables with Sex and BMI as control variables in block 2 and adding PA intentions in block 3. To test the second hypothesis (H2), automatic attitudes towards PA (d-score) were added in block 4. It has been suggested that the number of variables included in a regression model may inflate the explained variance due to overfitting (Núñez, Steyerberg, & Núñez, 2011). Therefore, in block 5, a post-hoc parsimonious model was built by excluding independent variables that did not contribute to the models in the three previous blocks. For each model, the R^2 value was reported as a measure of explained variance and indicator of how well the regression line fits the data with minimum error as the difference between observed and fitted values. The change in R^2 between subsequent models was reported as change in explained variance and its significance was tested using an F-test (Gelman & Hill, 2007). The Bonferroni outlier test (*car* R package) was used to test for extreme values in the residuals. Multiple linear regression assumptions were tested for the residuals to assess the model reliability, including normality of residuals (Kolmogorov-Smirnov test), independence of residuals (Durbin-Watson test with values substantially larger or smaller than 2 indicating violation of this assumption), homoscedasticity (homogeneity of variance; Breusch-Pagan test), and multicollinearity (using the variance inflation factor; VIF) (Williams, Grajales, & Kurkiewicz, 2013). Significance was set at $\alpha = 0.05$ for the interpretation of the results.

3. Results

In total, 79 children agreed to participate in the study, of whom three did not attend school on the days of data collection, three were excluded based on the SC-IAT reaction time exclusion criteria (≥10 % of trials ≤300 ms) and four were excluded based on the SC-IAT error rate exclusion criteria (>20 % of trials). The sample size included in the analysis was 69 participants, including 46 girls and 23 boys. See Table 2 for sample characteristics, and visualisation of the YAP in Fig. 2 and the predictor variables in Fig. 3. Trials were excluded based on the SC-IAT criteria (reaction time >300 ms and <10,000 ms) for 18 participants (trials excluded per participant mean = 2.2 %, SD = 2.3 %). The mean time to complete the SC-IAT was 7 min and 47 s (SD = 2 min, 41 s).

Table 2
Sample characteristics, including demographics and the measured constructs.

	Mean (SD)	Range
Demographics		
Age (years)	10.84 (0.56)	9.22–11.78
Height (cm)	149.16 (7.78)	131.00–171.00
Body mass (kg)	42.35 (10.26)	25.8–71.18
BMI	18.87 (3.37)	13.35–28.15
BMI z-score	1.17 (1.91)	−1.58-6.28
Dependent variable		
PA (At + Out of school)	7.04 (1.43)	3.60–9.80
At school	3.77 (0.85)	1.40–5.00
Out of school	3.27 (0.86)	1.40–5.00
Sedentary	2.41 (0.74)	1.20–4.60
Independent variables		
PA self-efficacy	3.66 (0.50)	2.13–4.87
PA intention	3.93 (0.91)	1.33–5.00
Explicit affective attitudes	8.50 (1.55)	4.50–10.00
Explicit instrumental attitudes	9.47 (0.90)	5.00–10.00
d-score	0.14 (0.22)	−0.33-0.63

PA = Physical activity; BMI = Body mass index;
SC-IAT = Single-Category Implicit Association Task;
RT = Reaction time; d-score = Score on the Single-Category Implicit Association Task

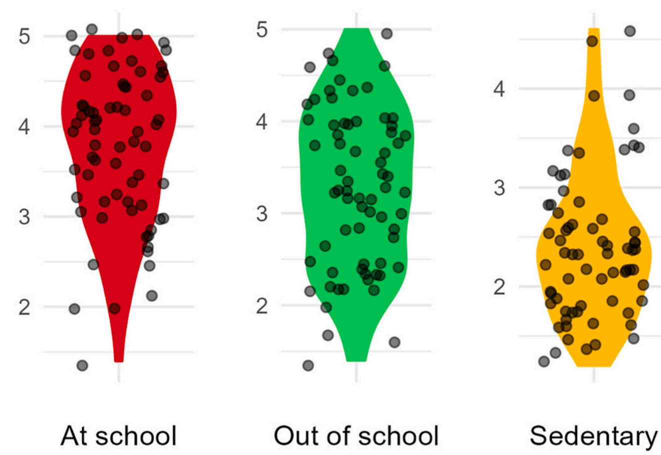

Fig. 2. Visualization of the youth activity profile for each of the three sections: physical activity at school and out of school and sedentary activity.

3.1. Associations between variables

Overall, the independent variables showed small-to-moderate positive associations with PA, except for BMI and d-score, which showed no significant associations with PA. The d-score showed only small significant positive associations with PA self-efficacy and PA intentions, and no associations with affective attitudes, instrumental attitudes, or PA. Instrumental attitudes showed no association with PA intentions. See Table 3 for a correlation matrix including predictor variables and the response variable.

3.2. Hierarchical multiple regression

Assumption checks were conducted on the residuals of the hierarchical multiple regression and all assumptions were met. Additionally, the VIF for all predictors were deemed satisfactory (VIFs <1.79). Detailed results of the hierarchical multiple regression are presented in

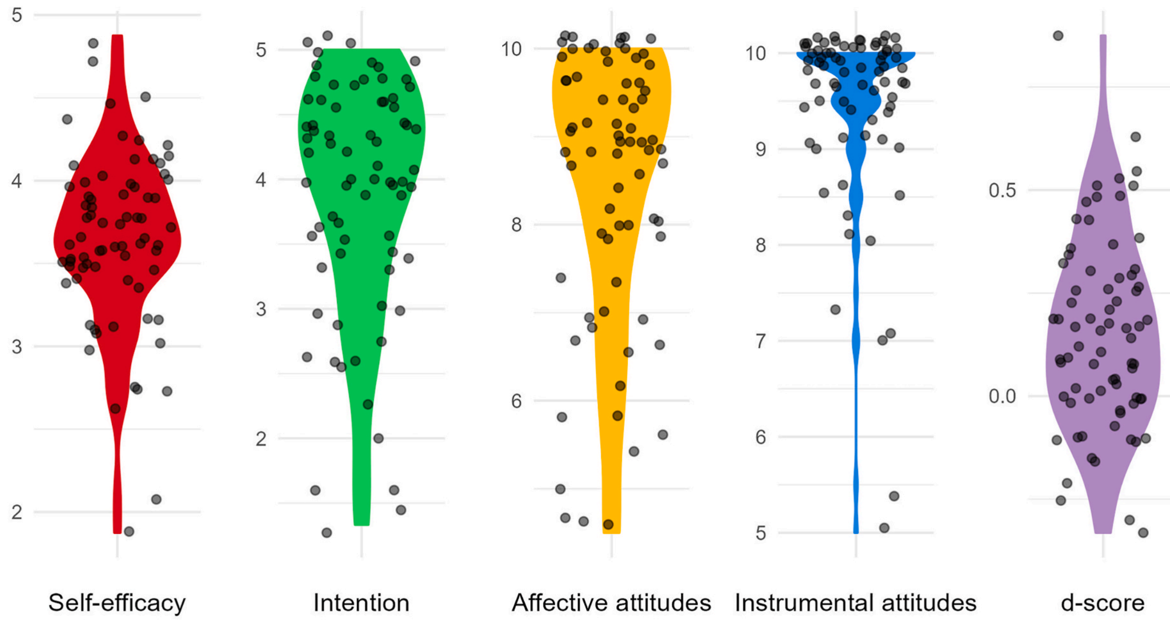

Fig. 3. Visualization of the data for each measurement: self-efficacy, intention, affective attitudes, instrumental attitudes, and d-score.

Table 3
Correlation matrix of the interrelationships among predictor and responses (PA) variables.

	1	2	3	4	5	6
1. Physical activity	-					
2. BMI	−0.13					
3. PA self-efficacy	0.46[c]	0.03				
4. PA intentions	0.40[c]	−0.07	0.44[c]			
5. Explicit affective attitudes	0.47[c]	−0.22	0.48[c]	0.20		
6. Explicit instrumental attitudes	0.19	−0.12	0.32[b]	−0.01	0.44[c]	
7. d-score	−0.004	−0.11	0.26[a]	0.49[c]	0.05	−0.09

BMI = Body Mass Index; PA = Physical Activity; d-score = score on Single-Category Implicit Association Task (SC-IAT)
[a] $p < 0.05$;
[b] $p < 0.01$;
[c] $p < 0.001$

Table 4. The regression models in blocks 2–6 indicated significant explained variance in PA. In block 1, Sex and BMI showed no association with PA, explaining 0.1 % of variance. In block 2, affective attitudes and PA self-efficacy were significantly associated with PA, explaining 25.3 % of variance. In block 3, when PA intentions were included in the model, PA self-efficacy was no longer significantly associated with PA, thereby suggesting that the effect of PA self-efficacy on PA was largely explained by PA intentions. Affective attitudes and PA intentions were significantly associated with PA, explaining 28.3 % of variance, with a non-significant change in explained variance, $F(1,61) = 3.59$; $p = 0.063$. In block 4, when automatic attitudes (d-score) were included in the model, affective attitudes and PA intentions remained significantly associated with PA, and a significant association between automatic attitudes and PA emerged, explaining significantly a further 4.7 % of variance in PA, $F(1,60) = 5.34$; $p = 0.024$. However, contrary to our expectations, a negative association between automatic attitudes and PA was observed. In block 5, a post-hoc model was built excluding instrumental attitudes, sex and BMI. A significant association remained between PA intentions, affective attitudes and automatic attitudes and PA, and the model was slightly strengthened explaining 35.0 % of variance in PA, but not significantly, $F(-1,61) = 0.24$; $p = 0.063$. The association between automatic attitudes and PA remained negative, which could be attributed to a potential suppressive effect. Therefore, an additional block (block 6) was added to the hierarchical regression to test whether removing affective attitudes from the model influenced the direction of the association between automatic attitudes and PA. In block 6, the association between automatic attitudes and PA was still negative and significant and the explained variance in PA dropped significantly by 6.2 %, $F(-1,62) = 5.30$; $p = 0.024$, suggesting that a suppressive effect of affective attitudes on automatic attitudes did not exist.

4. Discussion

The aim of the current study was to investigate the unique association of automatic attitudes towards PA on self-reported seven-day PA recall, after accounting for the effects of known controlled precursors of PA (i.e., explicit attitudes, PA self-efficacy, and PA intentions). The findings provided partial support for the two hypotheses: (H1) Controlled processes (affective attitudes and PA self-efficacy, but not instrumental attitudes) were associated with PA in children. When PA intentions were added to the regression as an independent variable, affective attitudes were associated with PA (but not instrumental attitudes or PA self-efficacy), explaining 28.3 % of the variance. As such, the results in blocks 2 and 3 of the regression were consistent with known social-cognitive theories (Ajzen, 1991; Bandura, 2001) and previous studies (Foley et al., 2008; Sheeran, Maki, et al., 2016a), that is, PA self-efficacy is associated with PA through PA intentions. (H2) In partial support of this hypothesis, automatic attitudes were associated with PA in children, only after adjustment for the controlled processes. However, the association was of small effect size (4.7 % of additional explained variance) and was in the opposite direction than expected, indicating that more positive automatic attitudes towards PA (higher d-score) were associated with lower PA. Additionally, further exploration revealed that the association between automatic attitudes towards PA and PA remained significant and negative in the absence of affective attitudes.

The correlational analysis showed significant associations between explicit instrumental and affective attitudes, respectively and PA, which is consistent with previous studies in adults (La Barbera & Ajzen, 2022). Studies in adults have shown a distinction between explicit instrumental and affective attitudes in the association with PA, with explicit affective attitudes showing stronger associations with PA than instrumental attitudes (Calitri et al., 2009; La Barbera & Ajzen, 2022; Phipps et al.,

Table 4
Hierarchical multiple regression of explicit affective and instrumental attitudes towards physical activity (PA), automatic attitudes towards PA, PA self-efficacy and PA intentions on PA. Block 1 included an initial test of the control variables. Block 2 and 3 tested whether self-efficacy would also be significantly associated with PA through PA intentions. Block 4 also included automatic attitudes to test its association with PA above and beyond the included controlled processes. In Block 5, variables that did not contribute to the model excluded in a parsimonious model. In Block 6, explicit affective attitudes were excluded to test whether it had a suppressive effect on automatic attitudes.

	b	SE	CI95 % (L, U)	t	p
Block 1: F(2,65) = 1.02; p = 0.355; R^2 = 0.030; Adjusted R^2 = 0.001					
Intercept	9.46	1.28	6.90, 12.03	7.37	<0.001
Sex	−0.38	0.38	−1.13, 0.37	−1.01	0.318
BMI	−0.06	0.05	−0.17, 0.04	−1.18	0.242
Block 2: F(5,62) = 5.53; p < 0.001; R^2 = 0.309; Adjusted R^2 = 0.253					
Intercept	2.54	2.20	−1.84, 6.93	1.16	0.251
PA self-efficacy	0.87	0.37	0.14, 1.6	2.38	0.021
Explicit affective attitudes	0.33	0.13	0.08, 0.58	2.64	0.011
Explicit instrumental attitudes	−0.11	0.19	−0.48, 0.27	−0.57	0.572
Sex	0.00	0.34	−0.67, 0.67	0.01	0.993
BMI	−0.03	0.05	−0.12, 0.07	−0.54	0.594
Block 3: F(6,61) = 5.42; p < 0.001; R^2 = 0.347; Adjusted R^2 = 0.283					
Intercept	2.02	2.17	−2.32, 6.36	0.93	0.356
PA self-efficacy	0.58	0.39	−0.2, 1.36	1.48	0.145
PA intentions	0.39	0.20	−0.02, 0.79	1.90	0.043
Explicit affective attitudes	0.30	0.12	0.05, 0.54	2.38	0.021
Explicit instrumental attitudes	−0.04	0.19	−0.41, 0.34	−0.20	0.842
Sex	−0.19	0.34	−0.87, 0.5	−0.54	0.591
BMI	−0.02	0.05	−0.12, 0.07	−0.51	0.614
Block 4: F(7,60) = 5.72; p < 0.001; R^2 = 0.400; Adjusted R^2 = 0.330					
Intercept	1.75	2.10	−2.44, 5.95	0.84	0.407
PA self-efficacy	0.72	0.38	−0.05, 1.48	1.87	0.066
PA intentions	0.56	0.21	0.14, 0.98	2.65	0.010
Explicit affective attitudes	0.28	0.12	0.04, 0.52	2.33	0.023
Explicit instrumental attitudes	−0.09	0.18	−0.45, 0.28	−0.49	0.628
d-score	−1.78	0.77	−3.33, −0.24	−2.31	0.024
Sex	−0.09	0.33	−0.76, 0.58	−0.27	0.790
BMI	−0.03	0.05	−0.13, 0.06	−0.75	0.457
Block 5 F(4, 64) = 10.17; p < 0.001; R^2 = 0.389; Adjusted R^2 = 0.350					
Intercept	0.36	1.13	−1.89, 2.61	0.32	0.752
PA self-efficacy	0.64	0.35	−0.07, 1.34	1.81	0.075
PA intentions	0.57	0.19	0.19, 0.95	3.02	0.004
Explicit affective attitudes	0.28	0.10	0.07, 0.48	2.69	0.009
d-score	−1.70	0.74	−3.18, −0.22	−2.30	0.025
Block 6 F(3,65) = 10.18; p < 0.001; R^2 = 0.320; Adjusted R^2 = 0.288					
Intercept	1.12	1.14	−1.15, 3.4	0.99	0.328
PA self-efficacy	1.06	0.33	0.4, 1.72	3.23	0.002
PA intentions	0.59	0.20	0.19, 0.99	2.96	0.004
d-score	−1.88	0.77	−3.43, −0.34	−2.44	0.017

PA = Physical Activity; d-score = score on Single-Category Implicit Association Task (SC-IAT); BMI = Body Mass Index

2022). In children, Rhodes, Quinlan, Naylor, Warburton, and Blanchard (2021) showed that parent- and child-reported instrumental attitudes towards PA did not predict family PA (co-PA including parent and child) at any point during the intervention whereas affective attitudes were found to predict PA. The distinction between instrumental attitudes, which are based on the knowledge of the importance and utility of PA, and affective attitudes, which are based on affective valuations of PA, may be important to address in future studies in children. The results also showed small associations between automatic attitudes and PA self-efficacy and PA intentions, but not with PA or the explicit instrumental or affective attitudes. The lack of association between automatic attitudes and explicit attitudes is consistent with some previous findings in adults, suggesting that automatic and explicit attitudes both predict PA behavior but independently of each other (Hyde, Doerksen, Ribeiro, & Conroy, 2010).

The current study found that the univariate association between automatic attitudes and PA was not significant, and when controlled processes were accounted for, a significant negative association emerged, which was unexpected. The negative association was in the opposite direction of what was expected based on the tenets of dual-process theories and contradicted the findings in previous studies in children (Brand & Cheval, 2019). Although the evidence in children is limited, significant positive associations between automatic attitudes towards PA and PA have been observed, suggesting that an increase in automatic attitudes is associated with an increase in PA (Limmeroth & Raboldt, 2022; Mücke et al., 2021). Similarly, studies in adults have largely shown positive associations between automatic attitudes and PA across a variety of study designs (Chevance et al., 2019). As the univariate association between automatic attitudes and PA was not significant and a negative association emerged in the fully adjusted model, a suppressive effect of affective attitudes was suspected. That is, after accounting for the shared variance between the automatic and controlled processes, the residual association between automatic attitudes and PA became negative (Martinez Gutierrez & Cribbie, 2021). Explicit affective attitudes are theoretically close to automatic attitudes that are thought to result from the learned affective association between PA and affective experiences (Perugini, 2005; Phipps et al., 2022). In an additional block in the hierarchical regression, we further explored whether such a negative association was due to the inclusion of affective attitudes but found that the association was unchanged in their absence. Such results suggest that automatic attitudes and explicit affective attitudes may both contribute to PA behavior but independently of each other. Affective attitudes have not been accounted for in previous studies in children and a distinction between instrumental and affective attitudes was highlighted, giving grounds for a similar distinction to be made in future studies that test the automatic processes behind PA behavior regulation.

In addition to theoretical factors, methodological factors may explain the unexpected negative association between automatic attitudes and PA. The SC-IAT used to measure automatic attitudes in the current study was adapted to the child population to provide a more relatable environment, including intuitive happy/sad faces used to indicate positive/negative categories, age-appropriate words with positive/negative connotations, and age- and gender-neutral stimuli. Furthermore, the SC-IAT was administered on iPads with touch buttons for response and the task was administered in groups in a classroom setting. Data from cognitive tasks in classroom settings administered using tablets in children (7–13 years old), as done in the current study, has previously shown acceptable reliability (Bignardi, Dalmaijer, Anwyl-Irvine, & Astle, 2021). However, when comparing computers with tablets and smartphones (in adults), lower performance (slower reaction times and more mistakes) was found using tablets compared to computers, and small-screen devices (i.e., smartphones) showed the lowest performance (Passell et al., 2021). As such, the administration of the SC-IAT on iPads may have made its accuracy weaker compared to computer-based SC-IAT, which may explain the lack of bivariate association between automatic attitudes and PA. Moreover, previous studies in children have reported adapting the stimuli to elicit PA-related affective responses and using emoticons as positive/negative cues (Limmeroth & Raboldt, 2022; Mücke et al., 2021). The split-half reliability of the SC-IAT in the current study was slightly below acceptable level (r = 0.68), which could be explained by any of the above-mentioned adaptations. It has been suggested that measures of automatic attitudes generally show low reliability due to their indirect nature, relying on reaction times to infer automaticity (Zenko & Ekkekakis, 2019a). Furthermore, PA was measured using a self-report recall tool (YAP). The previous studies investigating the association between automatic attitudes towards PA and PA in children used device-measured PA, which may explain the contradicting results in the current study (Limmeroth & Raboldt, 2022; Mücke et al., 2021). As opposed to self-reported PA, device-based PA measurement does not rely on recall but is continuous and captures most movement using accelerations, and may provide a more accurate estimate of children's PA behavior (Burchartz et al., 2021; Fiedler, Eckert, Burchartz, Woll, & Wunsch, 2021). Finally, a hierarchical regression was used to test the stated hypotheses, which is particularly useful as it allows assessment of the change in explained variance (R^2) between subsequent models. Other analyses, such as structural equation models, could be used to test associations between predictor variables as well as the outcome variable.

The current study had some limitations. The sample size in the current study (n = 69) was under the one estimated through the prospective power analysis (n = 77). Enough participants were recruited (n = 79) but due to the aforementioned reasons 10 participants were excluded from analysis. Moreover, the current study employed a cross-sectional design, which limits any causal inference for the association between automatic attitudes toward PA and PA. Designs that involve multiple measures over time (e.g., longitudinal designs) provide higher levels of evidence as they account for any changes that occur in the measured constructs over time (Atkin, Van Sluijs, Dollman, Taylor, & Stanley, 2016). Studies with experimental manipulations may provide further causal evidence beyond correlational studies. Additionally, it should be noted that PA intention and explicit attitudes were measured in the current study using self-constructed questionnaires as, to the authors' knowledge, no validated questionnaires were available. As the validity of the self-constructed questionnaires has not been established, the results may have been influenced. For example, the PA intention questionnaire targeted three dimensions of PA that could be considered separate constructs. Additionally, the phrasing of the items in the PA intention questionnaire could be improved to account for potential differences in children's PA contexts, which could confound the scoring of the questionnaire. Thus, the development of valid and reliable tools to measure PA intention and explicit attitudes in children is therefore urgently needed. Furthermore, it should be noted that the current study addressed controlled processes described by the TPB as proximal predictors of PA but did not include subjective norms. Subjective norms are considered a distal construct, which is not directly linked to the behavior (PA). Nevertheless, the inclusion of subjective norms in future studies is warranted.

Some promising research has been conducted in adults to explore the roles of automatic processes in the regulation of PA behavior, including attentional bias, approach-avoidance tendencies and inhibitory control (Cheval, Sarrazin, Pelletier, & Friese, 2016; Cheval, Miller, et al., 2019; Farajzadeh et al., 2023; Kullmann et al., 2014). Only a few studies have explored automatic processes in the context of PA behavior regulation and focused on the child population, making the current study novel. An additional contribution of the current study was that it examined automatic and controlled processes conjointly, tapping into the potential unique contribution of automatic processes to PA regulation above and beyond controlled processes. The findings of the current study indicate that automatic processes may also have a role in the regulation of PA behavior in children. However, definitive conclusions cannot be drawn yet. The association between automatic attitudes and PA, and the interplay with controlled processes needs further investigation. Further research is also needed to investigate other automatic processes to better understand their roles in PA behavior regulation in children, including attentional bias, approach-avoidance tendencies, and inhibitory control. Special caution should be given to children who are still undergoing cognitive maturation and automatic processes may be important drivers of their PA behavior regulation (Burchartz et al., 2021; Tao et al., 2014). Finally, as automatic processes have mainly been investigated in adult populations, little research exists that considers the environmental influences on the formation of affective valuations of PA or the response to external PA stimuli in children. Perhaps unlike adults, the characteristics of external PA stimuli may not only reflect stored experiences during exercise. As children's PA is considered impulsive, the characteristics (social/physical) of PA stimuli that drive or restrain PA engagement need to be examined.

5. Conclusions

The current study shed light on the respective roles of automatic and controlled processes in PA behavior regulation in children. The current study found that automatic attitudes were associated with PA in children, with a negative association (contrary to expectation), with a small effect of 4.6 % additional explained variance above and beyond controlled processes and only present when accounting for controlled processes. Further examination of the association between automatic attitudes towards PA is needed to affirm the direction of the association and to establish how it underpins other automatic processes triggered by PA-related cues. Prospective designs relying on more reliable measure of automatic processes and PA behaviors in children are warranted.

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CRediT authorship contribution statement

Mohammed Khudair: Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Boris Cheval:** Writing – review & editing, Formal analysis, Conceptualization. **Fiona Chun Man Ling:** Writing – review & editing, Supervision. **Florentina Johanna Hettinga:** Writing – review & editing, Supervision. **Gavin Daniel Tempest:** Writing – review & editing, Supervision, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data has been made available through Figshare.

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References

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*, 179–211. https://doi.org/10.1016/0749-5978(91)90020-T

Andrews, J. A., Hampson, S. E., Greenwald, A. G., Gordon, J., & Widdop, C. (2011). Using the implicit association test to assess children's implicit attitudes toward smoking. *Journal of Applied Spocial Psychology, 40*(9), 2387–2406. https://doi.org/10.1111/j.1559-1816.2010.00663.x.Using

Atkin, A. J., Van Sluijs, E. M. F., Dollman, J., Taylor, W. C., & Stanley, R. M. (2016). Identifying correlates and determinants of physical activity in youth: How can we advance the field? *Preventive Medicine, 87*, 167–169. https://doi.org/10.1016/j.ypmed.2016.02.040

Axt, J. R., Feng, T. Y., & Bar-Anan, Y. (2021). The good and the bad: Are some attribute words better than others in the Implicit Association Test? *Behavior Research Methods, 53*(6), 2512–2527. https://doi.org/10.3758/s13428-021-01592-8

Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual Review of Psychology, 52*, 1–26. https://doi.org/10.1146/annurev.psych.52.1.1

Baron, A. S., & Banaji, M. R. (2006). The development of implicit attitudes: Evidence of race evaluations from ages 6 and 10 and adulthood. *Psychological Science, 17*(1), 53–58. https://doi.org/10.1111/j.1467-9280.2005.01664.x

Bignardi, G., Dalmaijer, E. S., Anwyl-Irvine, A., & Astle, D. E. (2021). Collecting big data with small screens: Group tests of children's cognition with touchscreen tablets are reliable and valid. *Behavior Research Methods, 53*(4), 1515–1529. https://doi.org/10.3758/s13428-020-01503-3

Blanton, H., Jaccard, J., & Burrows, C. N. (2015). Implications of the implicit association test D-transformation for psychological assessment. *Assessment, 22*(4), 429–440. https://doi.org/10.1177/1073191114551382

Brand, R., & Cheval, B. (2019). Theories to explain exercise motivation and physical inactivity: Ways of expanding our current theoretical perspective. *Frontiers in Psychology, 10*(MAY), 1–4. https://doi.org/10.3389/fpsyg.2019.01147

Brand, R., & Ekkekakis, P. (2018). Affective–Reflective Theory of physical inactivity and exercise: Foundations and preliminary evidence. *German Journal of Exercise and Sport Research, 48*(1), 48–58. https://doi.org/10.1007/s12662-017-0477-9

Brown, H. E., Atkin, A. J., Panter, J., Wong, G., Chinapaw, M. J. M., & Sluijs, E. M. F. V. (2016). Family-based interventions to increase physical activity in children: A systematic review , meta-analysis and realist synthesis. *April*, 345–360. https://doi.org/10.1111/obr.12362

Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G., Carty, C., Chaput, J. P., Chastin, S., Chou, R., Dempsey, P. C., Dipietro, L., Ekelund, U., Firth, J., Friedenreich, C. M., Garcia, L., Gichu, M., Jago, R., Katzmarzyk, P. T., … Willumsen, J. F. (2020). World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *British Journal of Sports Medicine, 54*(24), 1451–1462. https://doi.org/10.1136/bjsports-2020-102955

Burchartz, A., Oriwol, D., Kolb, S., Schmidt, S. C. E., Wunsch, K., Manz, K., Niessner, C., & Woll, A. (2021). Comparison of self-reported & device-based, measured physical activity among children in Germany. *BMC Public Health, 21*(1), 1081. https://doi.org/10.1186/s12889-021-11114-y

Calitri, R., Lowe, R., Eves, F. F., & Bennett, P. (2009). Associations between visual attention, implicit and explicit attitude and behaviour for physical activity. *Psychology and Health, 24*(9), 1105–1123. https://doi.org/10.1080/08870440802245306

Cheval, B., & Boisgontier, M. P. (2021). The theory of effort minimization in physical activity. *Exercise and Sport Sciences Reviews, 49*(3), 168–178. https://doi.org/10.1249/JES.0000000000000252

Cheval, B., Boisgontier, M. P., Bacelar, M. F. B., Feiss, R., & Miller, M. W. (2019). Opportunities to sit and stand trigger equivalent reward-related brain activity. *International Journal of Psychophysiology, 141*, 9–17. https://doi.org/10.1016/j.ijpsycho.2019.04.009

Cheval, B., Miller, M. W., Orsholits, D., Berry, T., Sander, D., & Boisgontier, M. P. (2019). Physically active individuals look for more: An eye-tracking study of attentional bias. *Psychophysiology, 57*(6). https://doi.org/10.1111/psyp.13582

Cheval, B., Sarrazin, P., Isoard-Gautheur, S., Radel, R., & Friese, M. (2015). Reflective and impulsive processes explain (in)effectiveness of messages promoting physical activity: A randomized controlled trial. *Health Psychology, 34*(1), 10–19. https://doi.org/10.1037/hea0000102

Cheval, B., Sarrazin, P., Pelletier, L., & Friese, M. (2016). Effect of retraining approach-avoidance tendencies on an exercise task: A randomized controlled trial. *Journal of Physical Activity and Health, 13*(12), 1396–1403. https://doi.org/10.1123/jpah.2015-0597

Cheval, B., Tipura, E., Burra, N., Frossard, J., Chanal, J., Orsholits, D., Radel, R., & Boisgontier, M. P. (2018). Avoiding sedentary behaviors requires more cortical resources than avoiding physical activity: An EEG study. *Neuropsychologia, 119*, 68–80. https://doi.org/10.1016/j.neuropsychologia.2018.07.029

Chevance, G., Bernard, P., Chamberland, P. E., & Rebar, A. (2019). The association between implicit attitudes toward physical activity and physical activity behaviour: A systematic review and correlational meta-analysis. *Health Psychology Review, 13* (3), 248–276. https://doi.org/10.1080/17437199.2019.1618726

Conroy, D. E., & Berry, T. R. (2017). Automatic affective evaluations of physical activity. *Exercise and Sport Sciences Reviews, 45*(4), 230–237. https://doi.org/10.1249/JES.0000000000000120

Conroy, D. E., Hyde, A. L., Doerksen, S. E., & Ribeiro, N. F. (2010). Implicit attitudes and explicit motivation prospectively predict physical activity. *Annals of Behavioral Medicine, 39*(2), 112–118. https://doi.org/10.1007/s12160-010-9161-0

Craeynest, M., Crombez, G., Houwer, J. D., Deforche, B., Tanghe, A., & Bourdeaudhuij, I. D. (2005). Explicit and implicit attitudes towards food and physical activity in childhood obesity. *Behaviour Research and Therapy, 43*(9), 1111–1120. https://doi.org/10.1016/j.brat.2004.07.007

De Onis, M., Onyango, A. W., Borghi, E., Siyam, A., Nishida, C., & Siekmann, J. (2007). Development of a WHO growth reference for school-aged children and adolescents. *Bulletin of the World Health Organization, 85*(9), 660–667. https://doi.org/10.2471/BLT.07.043497

De Vet, H. C. W., Mokkink, L. B., Mosmuller, D. G., & Terwee, C. B. (2017). Spearman–Brown prophecy formula and Cronbach's alpha: Different faces of reliability and opportunities for new applications. *Journal of Clinical Epidemiology, 85*, 45–49. https://doi.org/10.1016/j.jclinepi.2017.01.013

DeJesus, J. M., Gelman, S. A., & Lumeng, J. C. (2020). Children's implicit food cognition: Developing a food Implicit Association Test. *Cognitive Development, 54*, Article 100889. https://doi.org/10.1016/j.cogdev.2020.100889

Eisinga, R., Grotenhuis, M. T., & Pelzer, B. (2013). The reliability of a two-item scale: Pearson, Cronbach, or Spearman-Brown? *International Journal of Public Health, 58*(4), 637–642. https://doi.org/10.1007/s00038-012-0416-3

Erdfelder, E., Faul, F., & Buchner, A. (1996). Gpower: A general power analysis program. *Behavior Research Methods, Instruments, & Computers, 28*(1), 1–11. https://doi.org/10.3758/BF03203630

Farajzadeh, A., Goubran, M., Beehler, A., Cherkaoui, N., Morrison, P., Chanaleilles, M. D., Maltagliati, S., Cheval, B., Miller, M. W., Sheehy, L., Bilodeau, M., Orsholits, D., & Boisgontier, M. P. (2023). Automatic approach-avoidance tendency toward physical activity, sedentary, and neutral stimuli as a function of age. *Explicit affective attitude, and intention to be active*.

Farooq, M. A., Parkinson, K. N., Adamson, A. J., Pearce, M. S., Reilly, J. K., Hughes, A. R., Janssen, X., Basterfield, L., & Reilly, J. J. (2018). Timing of the decline in physical activity in childhood and adolescence: Gateshead Millennium Cohort Study. *British Journal of Sports Medicine, 52*(15), 1002–1006. https://doi.org/10.1136/bjsports-2016-096933

Feil, K., Fritsch, J., & Rhodes, R. E. (2023). The intention-behaviour gap in physical activity: A systematic review and meta-analysis of the action control framework. *British Journal of Sports Medicine, 57*(19), 1265–1271. https://doi.org/10.1136/bjsports-2022-106640

Fiedler, J., Eckert, T., Burchartz, A., Woll, A., & Wunsch, K. (2021). Comparison of self-reported and device-based measured physical activity using measures of stability, reliability, and validity in adults and children. *Sensors, 21*(8), 2672. https://doi.org/10.3390/s21082672

Foley, L., Prapavessis, H., Maddison, R., Burke, S., McGowan, E., & Gillanders, L. (2008). Predicting physical activity intention and behavior in school-age children. *Pediatric Exercise Science, 20*(3), 342–356. https://doi.org/10.1123/pes.20.3.342

Gardner, B., Rebar, A. L., De Wit, S., & Lally, P. (2024). What is habit and how can it be used to change real-world behaviour? Narrowing the theory-reality gap. *Social and Personality Psychology Compass, 18*(6), Article e12975. https://doi.org/10.1111/spc3.12975

Gelman, A., & Hill, J. (2007). *Data analysis using regression and multilevel/hierarchical models*.

Gourlan, M., Bernard, P., Bortolon, C., Romain, A. J., Lareyre, O., Carayol, M., Ninot, G., & Boiché, J. (2016). Efficacy of theory-based interventions to promote physical activity. A meta-analysis of randomised controlled trials. *Health Psychology Review, 10*(1), 50–66. https://doi.org/10.1080/17437199.2014.981777

Greenwald, A. G., Nosek, B. A., & Banaji, M. R. (2003). Understanding and using the implicit association test: I. An improved scoring algorithm. *Journal of Personality and Social Psychology, 85*(2), 197–216. https://doi.org/10.1037/0022-3514.85.2.197

Griffiths, L. J., Cortina-Borja, M., Sera, F., Pouliou, T., Geraci, M., Rich, C., Cole, T. J., Law, C., Joshi, H., Ness, A. R., Jebb, S. A., & Dezateux, C. (2013). How active are our children? Findings from the millennium cohort study. *BMJ Open, 3*(8), 1–10. https://doi.org/10.1136/bmjopen-2013-002893

Guthold, R., Stevens, G. A., Riley, L. M., & Bull, F. C. (2020). Global trends in insufficient physical activity among adolescents: A pooled analysis of 298 population-based surveys with 1·6 million participants. *The Lancet Child and Adolescent Health, 4*(1), 23–35. https://doi.org/10.1016/S2352-4642(19)30323-2

Hyde, A. L., Doerksen, S. E., Ribeiro, N. F., & Conroy, D. E. (2010). The independence of implicit and explicit attitudes toward physical activity: Introspective access and attitudinal concordance. *Psychology of Sport and Exercise, 11*(5), 387–393. https://doi.org/10.1016/j.psychsport.2010.04.008

Hyde, A. L., Elavsky, S., Doerksen, S. E., & Conroy, D. E. (2012). The stability of automatic evaluations of physical activity and their relations with physical activity. *Journal of Sport & Exercise Psychology, 34*(6), 715–736. https://doi.org/10.1123/jsep.34.6.715

Inquisit Web. (2023). [Computer software]. https://www.millisecond.com.

Judah, G., Gardner, B., Kenward, M. G., DeStavola, B., & Aunger, R. (2018). Exploratory study of the impact of perceived reward on habit formation. *BMC Psychology, 6*(1), 62. https://doi.org/10.1186/s40359-018-0270-z

Karpinski, A., & Steinman, R. B. (2006). The single category implicit association test as a measure of implicit social cognition. *Journal of Personality and Social Psychology, 91* (1), 16–32. https://doi.org/10.1037/0022-3514.91.1.16

Kullmann, S., Giel, K. E., Hu, X., Bischoff, S. C., Teufel, M., Thiel, A., Zipfel, S., & Preissl, H. (2014). Impaired inhibitory control in anorexia nervosa elicited by physical activity stimuli. *Social Cognitive and Affective Neuroscience, 9*(7), 917–923. https://doi.org/10.1093/scan/nst070

La Barbera, F., & Ajzen, I. (2022). Instrumental vs. experiential attitudes in the theory of planned behaviour: Two studies on intention to perform a recommended amount of physical activity. *International Journal of Sport and Exercise Psychology*, 1–13. https://doi.org/10.1080/1612197X.2022.2161107

Limmeroth, J., & Raboldt, M. (2022). "I do what I like": 8- to 10-year-old children's physical activity behavior is already interrelated with their automatic affective processes. *Journal of Sport & Exercise Psychology, 44*(2), 138–147. https://doi.org/10.1123/jsep.2021-0251

Martinez Gutierrez, N., & Cribbie, R. (2021). Incidence and interpretation of statistical suppression in psychological research. *Canadian Journal of Behavioural Science/Revue Canadienne des Sciences du Comportement, 53*(4), 480–488. https://doi.org/10.1037/cbs0000267

Melnikoff, D. E., & Bargh, J. A. (2018). The mythical number two. *Trends in Cognitive Sciences, 22*(4), 280–293. https://doi.org/10.1016/j.tics.2018.02.001

Motl, R. W., Dishman, R. K., Trost, S. G., Saunders, R. P., Dowda, M., Felton, G., Ward, D. S., & Pate, R. R. (2000). Factorial validity and invariance of questionnaires measuring social-cognitive determinants of physical activity among adolescent girls. *Preventive Medicine, 31*(5), 584–594. https://doi.org/10.1006/pmed.2000.0735

Mücke, M., Ludyga, S., Andrä, C., Gerber, M., & Herrmann, C. (2021). Associations between physical activity, basic motor competencies and automatic evaluations of exercise. *Journal of Sports Sciences, 39*(16), 1903–1909.

Muschalik, C., Elfeddali, I., Candel, M. J. J. M., & de Vries, H. (2018). A longitudinal study on how implicit attitudes and explicit cognitions synergistically influence physical activity intention and behavior. *BMC Psychology, 6*(1), 18. https://doi.org/10.1186/s40359-018-0229-0

Myatt, M., & Guevarra, E. (2019). *zscorer: An Anthropometric z-score Calculator* [Computer software]. *R package version 0.3.1*. https://nutriverse.io/zscorer/.

Nosek, B. A. (2007). Implicit–explicit relations. *Current Directions in Psychological Science, 16*(2), 65–69. https://doi.org/10.1111/j.1467-8721.2007.00477.x

Núñez, E., Steyerberg, E. W., & Núñez, J. (2011). Regression modeling strategies. *Revista Española de Cardiología (English Edition), 64*(6), 501–507. https://doi.org/10.1016/j.rec.2011.01.017

Parsons, S. (2021). splithalf: Robust estimates of split half reliability. *Journal of Open Source Software, 6*(60), 3041. https://doi.org/10.21105/joss.03041

Passell, E., Strong, R. W., Rutter, L. A., Kim, H., Scheuer, L., Martini, P., Grinspoon, L., & Germine, L. (2021). Cognitive test scores vary with choice of personal digital device. *Behavior Research Methods, 53*(6), 2544–2557. https://doi.org/10.3758/s13428-021-01597-3

Perugini, M. (2005). Predictive models of implicit and explicit attitudes. *British Journal of Social Psychology, 44*(1), 29–45. https://doi.org/10.1348/014466604X23491

Phipps, D. J., Rhodes, R. E., Jenkins, K., Hannan, T. E., Browning, N. G., & Hamilton, K. (2022). A dual process model of affective and instrumental implicit attitude, self-monitoring, and sedentary behavior. *Psychology of Sport and Exercise, 62*, Article 102222. https://doi.org/10.1016/j.psychsport.2022.102222

R Core Team. (2019). *R: A language and environment for statistical computing.* R Foundation for Statistical Computing [Computer software] https://www.r-project.org/.

Rhodes, R., Quinlan, A., Naylor, P. J., Warburton, D. E. R., & Blanchard, C. M. (2021). Predicting family and child physical activity across six-months of a family-based intervention: An application of theory of planned behaviour, planning and habit. *Journal of Sports Sciences, 39*(13), 1461–1471. https://doi.org/10.1080/02640414.2021.1877460

Rhodes, R., & Rebar, A. L. (2017). Conceptualizing and defining the intention construct for future physical activity research. *Exercise and Sport Sciences Reviews, 45*(4), 209–216. https://doi.org/10.1249/JES.0000000000000127

Richetin, J., Costantini, G., Perugini, M., & Schönbrodt, F. (2015). Should we stop looking for a better scoring algorithm for handling implicit association test data? Test of the role of errors, extreme latencies treatment, scoring formula, and practice trials on reliability and validity. *PLoS One, 10*(6), Article e0129601. https://doi.org/10.1371/journal.pone.0129601

Saint-Maurice, P. F., & Welk, G. J. (2015). Validity and calibration of the youth activity profile. *PLoS One, 10*(12), 1–16. https://doi.org/10.1371/journal.pone.0143949

Sallis, J. F., Bull, F., Guthold, R., Heath, G. W., Inoue, S., Kelly, P., Oyeyemi, A. L., Perez, L. G., Richards, J., & Hallal, P. C. (2016). Progress in physical activity over the Olympic quadrennium. *The Lancet, 388*(10051), 1325–1336. https://doi.org/10.1016/S0140-6736(16)30581-5

Salter (9150 BK3R). (n.d.). [Computer software]. Salter.

Schinkoeth, M., & Antoniewicz, F. (2017). Automatic evaluations and exercising: Systematic review and implications for future research. *Frontiers in Psychology, 8* (DEC). https://doi.org/10.3389/fpsyg.2017.02103

Scotto Di Luzio, S., Martinent, G., Popa-Roch, M., Ballereau, M., Chahdi, S., Escudero, L., & Guillet-Descas, E. (2023). Obesity in childhood and adolescence: The role of motivation for physical activity, self-esteem, implicit and explicit attitudes toward obesity and physical activity. *Children, 10*(7), 1177. https://doi.org/10.3390/children10071177

Selya, A. S., Rose, J. S., Dierker, L. C., Hedeker, D., & Mermelstein, R. J. (2012). A practical guide to calculating cohen's f2, a measure of local effect size, from PROC MIXED. *Frontiers in Psychology, 3*. https://doi.org/10.3389/fpsyg.2012.00111

Sheeran, P., Bosch, J., Crombez, G., Hall, P., Harris, J., Papies, E., & Wiers, R. (2016a). Implicit processes in health psychology: Diversity and promise. *Health Psychology, 35* (8), 761–766.

Sheeran, P., Maki, A., Montanaro, E., Avishai-Yitshak, A., Bryan, A., Klein, W. M. P., Miles, E., & Rothman, A. J. (2016b). The impact of changing attitudes, norms, and self-efficacy on health-related intentions and behavior: A meta-analysis. *Health Psychology, 35*(11), 1178–1188. https://doi.org/10.1037/hea0000387

Sheeran, P., & Webb, T. L. (2016). The intention – behavior gap. *Social and Personality Psychology Compass, 10*(9), 503–518. https://doi.org/10.1111/spc3.12265

Tao, T., Wang, L., Fan, C., & Gao, W. (2014). Development of self-control in children aged 3 to 9 years: Perspective from a dual-systems model. *Scientific Reports, 4*(1), 7272. https://doi.org/10.1038/srep07272

Williams, M. N., Grajales, C. A. G., & Kurkiewicz, D. (2013). Assumptions of multiple regression: Correcting two misconceptions. *Practical Assessment, Research and Evaluation, 18*(11), 1–14. https://doi.org/10.7275/55HN-WK47

Zeileis, A., & Hothorn, T. (2002). Diagnostic checking in regression relationships. *R News, 2*(3), 7–10.

Zenko, Z., & Ekkekakis, P. (2019a). Critical review of measurement practices in the study of automatic associations of sedentary behavior, physical activity, and exercise. *Journal of Sport & Exercise Psychology, 41*(5), 271–288. https://doi.org/10.1123/jsep.2017-0349

Zenko, Z., & Ekkekakis, P. (2019b). Internal consistency and validity of measures of automatic exercise associations. *Psychology of Sport and Exercise, 43*, 4–15. https://doi.org/10.1016/j.psychsport.2018.12.005