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## **Application of the Trans-Contextual Model to Predict Change in Leisure Time Physical Activity**

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**Abstract**

**Objective:** This study tested effects of changes in the psychological constructs of the trans-contextual model (TCM) on changes in adolescents' outside of school moderate-to-vigorous physical activity (PA) measured using self-report and accelerometer-based device.

**Design:** A three-wave longitudinal design was used. High school students (N=331) completed measures of all the TCM constructs at Time1 and at Time2, five weeks apart. Self-reported PA behaviour was measured also at Time3, five weeks after Time2. PA was measured using accelerometer-based devices for seven days following Time1 and Time3 for a census week.

**Results:** A structural equation model using residual change scores revealed that perceived autonomy support from physical education (PE) teachers positively predicted autonomous motivation in PE. Autonomous motivation in PE positively predicted autonomous motivation in leisure time. Leisure-time autonomous motivation was positively and indirectly related to intention, mediated by attitude and perceived behavioural control. Intention positively predicted self-reported PA, and mediated the effect of autonomous motivation on self-reported PA. There were no effects on outside of school PA measured by accelerometer-based device.

**Conclusions:** Results provide qualified support for the TCM in the prediction of change in adolescents' leisure-time autonomous motivation, intention, and self-reported PA, but not change in PA measured by accelerometer-based device.

*Keywords:* Physical education, trans-contextual model, physical activity, residual change score

## Introduction

Epidemiological research has consistently demonstrated associations between physical activity and several adaptive psychological, cognitive, and physical health outcomes in children and adolescents (Poitras et al., 2016). However, the majority of adolescents do not meet guideline levels of physical activity (Guinhouya, Samouda, & Beaufort, 2013). Furthermore, levels of physical activity in this age group tend to decline with age (Farooq et al., 2018). Low levels of participation in physical activity during adolescence may contribute to increased risk of developing various chronic diseases in adulthood, which contribute to increased morbidity and lower quality of life (Mavrovouniotis, 2012).

Researchers have, therefore, sought to identify the psychological determinants of physical activity to provide essential formative evidence to inform the development of effective interventions to promote physical activity in adolescents. Research applying the trans-contextual model (TCM), a multi-theory model that integrates constructs and hypotheses from self-determination theory and social cognition theories, has identified that perceived autonomy support in a physical education (PE) context leads to higher self-reported physical activity outside of school among adolescents through autonomous motivation, social cognition beliefs, and intentions toward physical activity (Hagger & Chatzisarantis, 2012, 2016).

However, hypothesized relations among motivational and social cognition theories such as the TCM claim directional prediction (e.g., autonomous motivation in a given context (e.g., PE) predicts autonomous motivation in another context (e.g., leisure time)), which implies that constructs from the TCM should account for change over time. The value modeling change is that researchers can make stronger claim that affecting change in any one variable will lead to change in another. However, this is rarely done in tests of motivational and social cognition models including the TCM. To date, only one study has modelled change in these component

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constructs over time (Polet et al., 2020). If the predictions of the TCM hold when accounting for the *stability* of its constructs and behaviour over time, one is in a better position to claim that the model is effective in explaining *change* in its constructs and outcomes over time.

The current study aimed to apply the TCM to study motivational predictors of both self-reported and non-self-reported physical activity outside of school in adolescents using a longitudinal design that accounted for naturally-occurring stability in its constituent constructs over time. This approach advances findings of previous research applying the TCM research that has relied primarily on ‘static’ prediction of constructs over time and has not hitherto accounted for change.

### **Tenets of the Trans-Contextual Model**

The TCM proposes three key tenets derived from the integration of constructs and predictions from three theories: self-determination theory (Deci & Ryan, 1985), Vallerand’s hierarchical model of intrinsic and extrinsic motivation (Vallerand, 1997), and the theory of planned behaviour (Ajzen, 1991). The first key tenets of the trans-contextual model is that students’ perceptions of support for autonomous forms of motivation from self-determination theory by teachers in the educational environment (e.g., PE teachers in PE lessons) will be related to students’ autonomous motivation in that context (e.g., students autonomous motivation toward PE). Central to the theory is the distinction between autonomous and controlled forms of motivation (Deci & Ryan, 1985). Autonomous motivation comprises of intrinsic motivation (i.e., doing an activity for its inherent fulfilment rather than for a certain result), integrated regulation (i.e., doing an activity due to feeling a sense of integration within oneself), and identified regulation (i.e., acting to acquire self-endorsed outcomes), which are aligned toward one end of a continuum of relative autonomy (Ryan & Deci, 2000). On the other hand, controlled motivation is comprised of introjected regulation (i.e., behaving out of a sense of obligation, guilt or worry)

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and external regulation (i.e., acting in order to avoid sanctions or to receive a reward), and aligned toward the other end of the continuum. Forms of autonomous motivation on the continuum can be fostered by autonomy supportive behaviours displayed by leaders or authority figures in the actor's environment, such as PE teachers in students PE classes. Autonomy supportive behaviours include providing students with options and allowing them to choose, providing positive feedback, avoiding controlling language, and showing interest in students' physical activities outside of lessons. To the extent that students view their teachers as supporting their autonomous motivation and display autonomy supportive behaviours, pupils will be likely to express autonomous motivation in their PE classes.

The second tenet of the TCM proposes that forms of motivation with respect to activities in an educational context (e.g., school PE classes) will be transferred to forms of motivation with respect to similar activities in other contexts (e.g., physical activity in leisure time outside of school). Vallerand's (2007) hierarchical model forms the basis of this prediction. Vallerand's model proposes that cross-contextual inter-play occurs between motivation at the contextual level. Accordingly, the TCM predicts that autonomous motivation promoted in school by autonomy-supportive PE teachers relates to autonomous motivation toward physical activity in an out-of-school context (Hagger et al., 2003).

The final tenet of the TCM is that students' autonomous motivation toward activities in a leisure time out-of-school context is related to their future participation in those activities through sets of beliefs and intentions. The integration of the theory of planned behaviour with self-determination theory provides the basis for this prediction. Consistent with Deci and Ryan's (1985) original predictions, individuals' motives toward given target behaviour are likely to align their beliefs about the behaviour with their motives and are also likely to form intentions with respect to performing the behaviour in future consistent with those beliefs (Chan, Zhang, Lee, &

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Hagger, 2020; Hagger & Chatzisarantis, 2009). Specifically, autonomous motivation has been consistently linked to beliefs about outcomes (attitudes) and beliefs in capacity toward performing behaviours in future (perceived behavioural control), and is associated with intentions to perform the behaviour in future and actual behavioural engagement (Chatzisarantis, Hagger, Wang, & Thøgersen-Ntoumani, 2009; Hagger & Chatzisarantis, 2009; Jacobs et al., 2011). Controlled motivation is likely to be linked with individuals' beliefs that reflect pressure from significant others (subjective norms), and may also be linked to intentions and behaviour. Although, it must be stressed that controlled motivation tends only to be linked to persistence as long as the external contingencies are present, when they are removed behaviour is likely to desist. This is why controlled motivation does not always relate to behaviour persistence for many individuals. Consistent with research demonstrating that the environment created by PE teachers is important for fostering students' motivation toward PE (e.g., Girard & Lemoyne, 2018), research has indicated that perceived autonomy support from other sources in the out-of-school contexts, particularly from parents and peers, is also positively associated with autonomous motivation towards behaviour in that context. For example, peer and parent support for leisure-time physical activity is related to autonomous motivation toward that activity in that context (González-Cutre, Sicilia, Beas-Jiménez, & Hagger, 2014; Hagger et al., 2009; McDavid, Cox, & Amorose, 2012).

### **Predicting Physical Activity Measured by Self-Report and Accelerometer-Based Device**

The vast majority of studies using the TCM have been conducted in the area of PE and leisure time physical activity confirming the propositions proposed within the model (Hagger & Chatzisarantis, 2012, 2016). Previous studies testing the model have almost exclusively relied on self-report measures to evaluate adolescents' leisure time physical activity. However, self-report methods are likely subject to a considerable recall bias (Adams et al., 2005), which may

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contribute substantially to error variance and common method variance. This has previously been suggested by Ajzen who raised concerns over common method variance (1991). Such measures may have led to inflation of effects between TCM constructs and behaviour in previous studies. This has led researchers to suggest that studies should adopt means to measure physical activity that do not rely on self-report, such as accelerometer-based devices, in order to reduce bias and increase precision in behavioural prediction when testing the model (Hagger, Chatzisarantis, Barkoukis, Wang, & Baranowski, 2005). The present study aimed to explore this innovation in an application of the TCM.

### **A Residual Change Score Approach to the Trans-Contextual Model**

One of the limitations of many tests of social cognition and motivational models, including the TCM, is the use of prospective data in which constructs at a given time point are set as predictors of a target outcome of interest, usually a behavioural measure, over time. Although such data have some utility in identifying potential correlates of behavioural outcomes, they do not account for the natural change in constructs that occurs over time. Such change may be the function of individuals' reassessment of their beliefs and estimates due to new information coming to light. Prospective tests are limited because they do not model these changes. Residual change scores have been proposed to be a useful method in order to measure change in constructs over time while controlling for their covariance stability (Gollob & Reichardt, 1987; Prochaska, Velicer, Nigg, & Prochaska, 2008). For example, Rowan, McDermott, and Alles (2017) suggested that researchers should use residual change scores as the preferred method to assess intention stability in physical activity and permit an assessment of the extent to which changes in intentions account for changes in behaviour over time. In the current research, we aimed to use residual change scores of the TCM constructs to test the pattern of relationships over time. Modelling change in the TCM constructs has value because it tests whether the model



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is effective in accounting naturally occurring change in its constructs over time, rather than providing a static account of constructs measured at a particular point in time, which may vary or change as new information comes to light. Such a model offers more than mere static prediction and opens to possibility that the model can account for more dynamic changes in the motivational and social cognition determinants of out-of-school physical activity over time.

### **The Current Study**

The present study aimed to test the hypotheses of the TCM while accounting for change in model constructs over time using residual change scores. Moreover, this study examined whether the changes in students' perceived components of the model predict both the change in self-report and non-self-report measures of physical activity spent outside of school of adolescents over a period of five weeks. Use of a residual change score approach is expected to provide a more precise test of the TCM by accounting for naturally-occurring change in model constructs and physical activity. Model effects are expected to hold when accounting for change, suggesting that it is effective as means to explain changes in behaviour over time. Finally, the current study aimed to investigate the influence of perceived autonomy support from the parents' and peers' autonomy support on adolescents' behaviour. Based on previous research on the TCM, the hypotheses of the current study are summarized in Table 1 and depicted in Figure 1.

Briefly, in terms of direct effects, change in perceived autonomy support is expected to have direct effects on change in autonomous motivation in PE ( $H_1$ ), and changes in autonomous motivation and controlled motivation on in PE are expected to predict changes in autonomous motivation ( $H_2$ ) and controlled motivation ( $H_3$ ) in leisure time. Change in perceived autonomy support from parents and peers is expected to predict change in autonomous motivation in leisure time ( $H_4$ ). Change in autonomous motivation in leisure time is expected to predict changes in attitudes ( $H_5$ ) and perceived behavioural control (PBC;  $H_6$ ), and change in controlled motivation

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expected to predict change in subjective norms (H<sub>7</sub>), in the same context. Changes in attitudes (H<sub>8</sub>), subjective norm (H<sub>9</sub>), and PBC (H<sub>10</sub>) were expected to predict changes in intentions, and changes in intentions (H<sub>11</sub>) and PBC (H<sub>12</sub>) were expected to predict change in behaviour. In terms of indirect effects, we expected indirect effects of change in perceived autonomy support from PE teachers on changes in autonomous motivation in leisure time mediated by change in autonomous motivation in PE (H<sub>13</sub>), and indirect effects of changes in parents and peers autonomy support on changes in attitudes (H<sub>14</sub>) and PBC (H<sub>15</sub>), respectively, mediated by change in autonomous motivation in leisure time. Changes in autonomous motivation in PE was expected to predict change in intention for leisure time physical activity mediated by changes in autonomous motivation in leisure time and attitudes (H<sub>16</sub>) and PBC (H<sub>17</sub>). Changes in controlled motivation in PE was expected to predict change in intention mediated by changes in controlled motivation in leisure time and subjective norms (H<sub>18</sub>). Changes in autonomous motivation in leisure time was expected to predict change in physical activity behaviour mediated by changes in intentions and attitude (H<sub>22</sub>) and PBC (H<sub>23</sub>), and change in controlled motivation in leisure time was expected to predict change in physical activity behaviour mediated by changes in intention and subjective norm (H<sub>24</sub>). Changes in attitude (H<sub>25</sub>) and PBC (H<sub>26</sub>) were expected to predict change in behaviour mediated by change in intention. Finally, we expected total effects of change in perceived autonomy support on changes in intention (H<sub>27</sub>) and physical activity behaviour (H<sub>28</sub>) mediated by the entire motivational sequence of the model.

[Table 1 near here]

[Figure 1 near here]

## Method

### Participants and Procedures

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Participants were secondary school students ( $N = 560$ , male,  $n = 357$ , female,  $n = 204$ ;  $M$  age = 13.8 years,  $SD = .95$ , range 11-15) enrolled in schools ( $N = 16$ ) in three urban districts. The study adopted a three-wave longitudinal survey design with participants completing psychological and self-reported physical activity behavioural measures at an initial point in time (Time 1) and the same variables were measured again at a subsequent point in time, five weeks later (Time 2). Self-reported physical activity behaviour was also collected at a third time point (Time 3), five weeks after Time 2. In addition, physical activity was measured using accelerometer-based devices for seven days following Time 1 and Time 3. All measures were completed twice to allow the modelling of change in study constructs using residual change scores. Measures of the TCM constructs were: perceived autonomy support from teachers in a PE, and from parents and peers in a leisure time context; perceived locus of causality in PE (Hagger & Chatzisarantis, 2003) and leisure-time contexts (Ryan & Connell, 1989); and physical activity intentions, attitudes, subjective norms, and perceived behavioural control from the theory of planned behaviour (Ajzen, 1991). The five-week period between data collection occasions was used to allow for longer-range prediction than is frequently used in model tests (Hagger, Polet, & Lintunen, 2018).

The study was approved by the local University research ethics committee. Permission from school administrators was obtained prior to data collection. Participants and their parents gave written informed consent for participation in the study. Students were informed that their responses reflected their opinions, that their responses may be different from those of others, and that there were no correct or incorrect answers. Questionnaires were completed anonymously and matched using an individual code with numbers and letters based on participants' initials, birth date, gender, class, and accelerometer-based device number. The students from all schools

completed all three time-points of data collection within the period from October 2017 to May 2018.

### **Measures**

TCM constructs including perceived autonomy support, and motivation were measured on validated psychometric instruments with responses provided on 7-point scales (1 = *strongly disagree* and 7 = *strongly agree*).

**Perceived autonomy support.** Students' perceived autonomy support from PE teachers, peers, and parents was measured using a short form of the Perceived Autonomy Support Scale for Exercise Settings (PASSES; Hagger et al., 2007). Each subscale contained four items (e.g., "I feel that my PE teacher/parents/friends provide me with choices, options, and suggestions about whether to do physical activity"). Previous studies have shown the PASSES to be a valid and reliable measure (e.g., Hagger et al., 2007).

**Autonomous and controlled motivation towards PE.** Students' autonomous and controlled forms of motivation toward PE were measured using an adapted version of the perceived locus of causality questionnaire (Goudas, Biddle, & Fox, 1994). Each subscale consisted of two items preceded by a common stem: "I do PE...". The stem was followed by sets of items measuring each regulation subscale: intrinsic motivation (e.g., "...because PE is fun"), identified regulation (e.g., "...because it is important to me to do well in PE"), introjected regulation (e.g., "...because I would feel bad if the teacher thought that I was not good at PE"), and external regulation (e.g., "...so that the teacher won't yell at me"). Average scores on the intrinsic motivation and identified regulation subscale items were used to form the autonomous motivation construct, and average of scores on the introjected regulation and external regulation items were used to form the controlled motivation construct. A perceived locus of causality

questionnaire for PE has been shown to be a valid and reliable measure (Hagger et al., 2005; Standage et al., 2012; Polet et al., 2020).

**Autonomous and controlled motivation during leisure time.** An adapted version of a perceived locus of causality questionnaire (Ryan & Connell, 1989) for leisure time was used to measure students' autonomous and controlled motivation during leisure time. Each subscale consisted of two items for each regulation style preceded by a common stem: "I do physical activity during my free time...". The stem was followed by items for the intrinsic motivation (e.g., "...because I enjoy doing physical activity"), identified regulation (e.g., "...because I value the benefits of physical activity"), introjected regulation (e.g., "...because I feel bad about myself if I don't do physical activity"), and external regulation (e.g., "...because I feel under pressure from people I know to do physical activity") subscales. The autonomous motivation construct was indicated by calculating the average of scores on the intrinsic motivation and identified regulation subscale items, controlled motivation construct was indicated by calculating the average of scores on the items for the introjected regulation and external regulation subscales. Previous studies have shown the questionnaire to be a valid and reliable measure (e.g., Hagger et al., 2005; Polet et al., 2020).

**Theory of planned behaviour constructs.** Measures of the theory of planned behaviour constructs were developed based on guidelines by Ajzen (2003). Intentions were measured by two items (e.g., "I intend to do active sports and/or vigorous physical activities during my leisure time in the next 5 weeks"). The measure of attitude comprised three 7-point semantic differential scales with bipolar adjectives: *bad-good*, *unenjoyable-enjoyable*, and *useless-useful* in response to the common stem: "Participating in active sports and/or vigorous physical activities during my leisure time in the next 5 weeks is ...". Subjective norms were measured on two items (e.g., "Most people who are important to me think I should do active sports and/or vigorous physical

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activities during my leisure time for the next 5 weeks”). Perceived behavioural control (i.e., PBC) was measured on two items (e.g., “How much control do you have over doing active sports and/or vigorous physical activities in my leisure time in the next 5 weeks”). Previous studies have shown measures of the theory constructs in school children to be valid and reliable (e.g., Pihu, Hein, Koka, & Hagger, 2008; Polet et al., 2020).

**Physical activity measured by accelerometer-based devices.** Participants’ moderate-to-vigorous physical activity in outside of school time was measured during a ‘census week’ at Time 1 and at Time 3 using Actigraph GT3X (ActiGraph LLC, Pensacola, FL, USA) accelerometer-based devices. Participants were instructed to wear the device on their waist for seven consecutive days during the census period, and to remove the device for sleeping and aquatic activities (e.g., bathing, swimming etc.) only. The sampling interval was set at 15 s. Data from the devices were considered valid if over 600 min (10 hours) of recorded data per day at least four days out of seven were present. For the purposes of the current study and consistent with the social cognition and motivational measures, moderate-to-vigorous physical activity in outside of school time encompassed all sports and other vigorous activities students performed outside of school hours. This means that physical activities of the requisite intensities performed for transportation, as well as other regular domestic (e.g., chores) and occupational (e.g., part-time employment) activities were also included, although many of these activities likely to fall into the ‘light’ category (Troost, Drovandi & Pfeiffer, 2016) and, therefore, were not incorporated into the measure. In addition, as the focus was on outside of school physical activity, physical activity data collected during the hours the participants spent at school were excluded from the analyses. Zero counts of consecutive 60 min were classified as non-wear time. The moderate-to-vigorous physical activity level in accelerometer-based devices was measured using

recommended cut-off points (i.e.,  $\geq 2296$  counts/min; Evenson, Catellier, Gill, Ondrak, & McMurray, 2008).

**Self-reported physical activity.** Self-reported leisure time physical activity was assessed at all time points using an adapted version of Godin and Shepherd's (1985) leisure time exercise questionnaire with two items: "How frequently have you participated in vigorous physical activities during your leisure time in the course of the past five weeks for at least 20 minutes at a time?" with responses reported on a 6-point scale (1 = *never* and 6 = *all of the time*) and "In the course of the past five weeks, how often on average, have you participated in vigorous physical activities during your leisure time for at least 20 minutes at a time?" with responses reported on a 6-point scale (1 = *not at all* and 6 = *most days per week*). The content of the items used (i.e., a minimum of 20 minutes of vigorous physical activity daily) were based on the guidelines of American College of Sport Medicine. Before answering to these two items students were presented with the definition of vigorous physical activity, which included all active sports and physical activities (e.g., sports training, practices, competition, continuous swimming, running etc.), but not sedentary sports (e.g., pool, darts) or walking to school. This measure has been used in previous studies to evaluate physical activity (Hagger et al., 2003; 2005; 2009; Polet et al., 2020).

### **Data Analyses**

Data analyses were performed using SPSS Version 23.0 (IBM Corp., Armonk, NY, USA) and SPSS AMOS Version 23.0 (IBM Corp., Armonk, NY, USA). Data were screened for missing values and distributional properties (Tabachnick & Fidell, 2007). Study hypotheses were tested using path analysis with residual change scores to account for the stability (change) in study constructs across the two time points. In the current study, residual change scores for each variable were calculated by regressing scores for variables measured at Time 2 on scores

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measured at Time 1, except self-report and accelerometer-based measures of physical activity where variable scores were calculated by regressing Time 3 scores on Time 1 scores. For example, the score for autonomous motivation in PE measured at Time 2 was regressed on the score for autonomous motivation in PE measured at Time 1. In the main analysis Time 2 scores of self-reported measure were not used in order to mirror the results with the accelerometer-based device<sup>1</sup>. Age and gender were included as covariates when computing the residual change score for each variable. Residual change scores can be interpreted as the amount of increase or decrease in the study variable scores between the two measurement occasions, taking into account the previous time point scores.

The main analysis involved a path analysis of the predictive relationships hypothesized in the TCM. Two models were estimated each with a different outcome variable: self-report physical activity and non-self-report physical activity. As Mardia's (1970) normalized coefficient indicated that the data deviated from multivariate normality (coefficients were 56.454 and 57.106, for the model using the accelerometer-based device to measure physical activity and the model using self-reported physical activity, respectively), we conducted our path analysis using a maximum likelihood estimation method with 5000 bootstrap re-samples (Byrne, 2010; Preacher & Hayes, 2008).

Overall model fit was evaluated using the following indices: the  $\chi^2$  coefficient, the comparative fit index (CFI), Bentler–Bonett non-normed fit index (NNFI), and root mean square error of approximation (RMSEA) and its 90% confidence interval (Hu & Bentler, 1995). Values exceeding .90 for the CFI and NNFI, and below .08 for the RMSEA, with narrow confidence intervals, are indicative of acceptable model fit.

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<sup>1</sup>We also calculated a change score for self-reported physical activity by using all time-points by regressing the scores for the physical activity measure taken at Time 3 on scores for the measure taken at Time 2 and Time 1. The model using this change score as an outcome is presented in Appendix B.



## Results

### Preliminary Analyses

Attrition across the three time points of data collection due to absences and problems with wearing the accelerometer-based device resulted in a final sample size of 331 participants (male = 91, female = 240;  $M$  age = 13.1,  $SD$  = .99, attrition rate = 40.9 %). Examination of skewness (range = -1.93 to 1.59) and kurtosis (range = -1.3 to 5.3) values suggested that all items, except one attitude item at Time 1 (skewness = -2.4; kurtosis = 7.92), were within acceptable ranges (Byrne, 2010). The descriptive statistics and intercorrelations for residual change scores, and internal consistency (Cronbach alpha) for all study variables at each time point are presented in Table 2. All alpha values exceeded  $>.70$  except for the subjective norm ( $\alpha$  = .64 and .65, at Time 1 and Time 2, respectively) and controlled motivation in PE ( $\alpha$  = .67 and .65, at Time 1 and Time 2, respectively) constructs. Descriptive statistics and intercorrelations for study variables at all time points are presented in Appendix A.

[Table 2 near here]

### Main Analyses<sup>2</sup>

Results of the path analysis testing hypothesized relationships within the model are presented in Figure 2. Covariances were added between perceived autonomy support from the PE teacher, parent and peer, between autonomous and controlled motivation at both PE and leisure time context, and between attitude, subjective norms and PBC. The models predicting physical activity measured by self-report ( $\chi^2 = 73.22$ ,  $df = 41$ ,  $p < .001$ ; CFI = .95.; NNFI = .92; RMSEA = .049; RMSEA 90% CI = .030–.067) and accelerometer-based devices ( $\chi^2 = 75.01$ ,  $df$

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<sup>2</sup> Data files, analysis scripts, and outputs including covariance matrices are available online at [https://osf.io/9xhe5/?view\\_only=acb04558e250424184fbb6badffdfc27](https://osf.io/9xhe5/?view_only=acb04558e250424184fbb6badffdfc27)

= 41,  $p < .001$ ; CFI = .95.; NNFI = .92; RMSEA = .050; RMSEA 90% CI = .032–.068)

demonstrated acceptable fit with the data.<sup>3</sup>

[Figure 2 near here]

**Direct effects.** Parameter estimates and bias-corrected bootstrapped 95% confidence intervals for the direct effects are presented in Table 3. Change in perceived autonomy support from PE teachers had a statistically significant direct effect on change in autonomous motivation in PE ( $H_1$ ;  $\beta = .26$ ,  $p = .001$ ). Change in autonomous motivation in PE had a significant direct effect on change in autonomous motivation in a leisure time context ( $H_2$ ;  $\beta = .29$ ,  $p = .001$ ). Change in controlled motivation in PE had a significant direct effect on change in controlled motivation in leisure time ( $H_3$ ;  $\beta = .40$ ,  $p = .001$ ). Change in perceived autonomy support from parents and peers had significant direct effects on the change in autonomous motivation in leisure time ( $H_4$ ;  $\beta = .32$ ,  $p = .001$  and  $\beta = .16$ ,  $p = .005$ , respectively).

Change in autonomous motivation in leisure time context had a statistically significant direct effect on change in attitude ( $H_5$ ;  $\beta = .37$ ,  $p = .001$ ) and PBC ( $H_6$ ;  $\beta = .33$ ,  $p = .001$ ). Change in controlled motivation in leisure time had a significant direct effect on the change in subjective norm ( $H_7$ ;  $\beta = .33$ ,  $p = .001$ ). Change in attitude ( $H_8$ ;  $\beta = .30$ ,  $p = .001$ ) and PBC ( $H_{10}$ ;  $\beta = .38$ ,  $p = .001$ ) had significant direct effects on change in intention.

Change in intention had a statistically significant direct effect on changes in physical activity measured by self-report ( $H_{11}$ ;  $\beta = .14$ ,  $p = .017$ ) but not by accelerometer-based devices ( $\beta = -.07$ ,  $p = .338$ ), so  $H_{11}$  was rejected for the latter model. Similarly, change in PBC had a

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<sup>3</sup> In the main analysis, the relationships between controlled motivation and attitude and between controlled motivation and PBC were not included to the models, however, alternative versions of the current models have been estimated in which direct effects of change in controlled motivation on change in PBC and attitude were included. Please see supplemental analyses in the Appendix C.

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significant direct effect on physical activity measured by self-report ( $H_{12}$ ;  $\beta = .20$ ,  $p = .002$ ) but by accelerometer-based devices ( $\beta = .05$ ,  $p = .515$ ), so  $H_{12}$  was rejected for the latter model.

**Indirect effects.** Parameter estimates and bias-corrected bootstrapped 95% confidence intervals for model indirect effects are presented in Table 3. The effect of the change in perceived autonomy support from the PE teacher on change in autonomous motivation in leisure time was mediated by change in autonomous motivation in PE ( $H_{13}$ ;  $\beta = .07$ ,  $p = .001$ ). The effect of change in perceived autonomy support from parents ( $\beta = .12$ ,  $p = .001$ ) and peers ( $\beta = .06$ ,  $p = .005$ ) on change in attitude was mediated by change in autonomous motivation in leisure time ( $H_{14}$ ). The effect of change in perceived autonomy support from parents ( $\beta = .11$ ,  $p = .001$ ) and peers ( $\beta = .05$ ,  $p = .005$ ) on change in PBC was mediated by change in autonomous motivation in leisure time ( $H_{15}$ ).

The effect of change in autonomous motivation in PE on the change in intention was mediated by change in autonomous motivation in leisure time and change in attitude ( $H_{16}$ ;  $\beta = .03$ ,  $p = .001$ ), and by change in autonomous motivation in leisure time and change in PBC ( $H_{17}$ ;  $\beta = .04$ ,  $p = .0001$ ). The effect of change in autonomous motivation in leisure time on change in intention was mediated by change in attitude ( $H_{19}$ ;  $\beta = .13$ ,  $p = .001$ ) and change in PBC ( $H_{20}$ ;  $\beta = .14$ ,  $p = .001$ ).

The effect of the change in autonomous motivation in leisure time on self-reported physical activity was mediated by change in attitude and change in intention ( $H_{22}$ ;  $\beta = .13$ ,  $p = .001$ ), and by change in PBC and change in intention ( $H_{23}$ ;  $\beta = .14$ ,  $p = .001$ ). The effect of change in attitude ( $H_{25}$ ;  $\beta = .04$ ,  $p = .017$ ) and PBC ( $H_{26}$ ;  $\beta = .05$ ,  $p = .017$ ) on the change in self-reported physical activity was mediated by change in intention. There were no indirect effects of change in attitude ( $H_{25}$ ;  $\beta = -.02$ ,  $p = .26$ ) and PBC ( $H_{26}$ ;  $\beta = -.03$ ,  $p = .25$ ) on change in physical activity measured by accelerometer-based devices.

[Table 3 near here]

### **Discussion**

The purpose of the current study was to test the effects of perceived autonomy support from PE teachers and autonomous motivation in PE on leisure time autonomous motivation, beliefs, intentions toward, and actual participation in, physical activity behaviour in a leisure time context. The study adopted an extended TCM that included additional sources of autonomy support from parents and peers, and used a unique three-wave longitudinal design that accounted for change in the constructs over time. In addition, the research also adopted accelerometer-based devices as an additional measure of physical activity, an advance on previous studies which have tended to rely exclusively on self-reports. The current study is innovative and extends previous research by accounting for construct stability in constructs within the TCM and eschews the typically static prediction of constructs over time used in standard cross-sectional and prospective designs. Results indicated that change in perceived autonomy support from PE teachers predicted changes in adolescents' autonomous motivation in PE, which, in turn, predicted changes in their autonomous motivation in leisure-time. Change in perceived autonomy support from peers and parents also predicted change in autonomous motivation in leisure time. Change in autonomous motivation in leisure time predicted change in intentions toward self-reported leisure time physical activity mediated by changes in attitude and PBC. However, these effects were not supported for outside of school physical activity measured by accelerometer-based devices.

Results of the current study confirm some of the key hypotheses of the TCM (Hagger & Chatzisarantis, 2012; 2016) using residual change scores, specifically effects of perceived autonomy support on autonomous motivation, the trans-contextual relationship between autonomous motivation between PE and leisure time physical activity contexts, and the effects of

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autonomous motivation on physical activity participation in leisure time through attitude, perceived behavioural control and intentions. The overall pattern of effects is in line with previous studies using the model (Gonzales-Cutre, Sicilia, Beas-Jimenez, & Hagger, 2014; Hagger et al., 2009; Pihu & Hein, 2007), including the effects from a recent meta-analysis (Hagger & Chatzisarantis, 2016). The unique contribution of these findings is that it demonstrates whether the model effects hold when accounting for inter-individual change in motivation, beliefs, and behaviour in the model over time. In tests of models that do not account for stability, often the strongest predictor of each construct over time is itself (i.e., the within-person stability of each construct). In such cases, such as in all previous tests of the TCM, such stability effects are not accounted for and therefore change is not modelled. This limits inferences that can be made regarding the capacity of the model to account for constructs that are likely to be subject to change over time, and has ramifications for the use of the data to inform interventions focused on behaviour change. The current research tests whether model predictions hold after accounting for naturally-occurring variability its constituent constructs over time. The residual change scores account for that stability, so the variance left that the real change in that construct over time i.e. change that cannot be attributed to the stability of that variable over time. As is often the case, variance in constructs is often largely attributable to its stability. So, by accounting for that variance, the residual change scores exclude the proportion of the variance attributable to change and, therefore, effect sizes using change scores are often smaller (Adachi & Willoughby, 2015). That the current model predictions in the TCM largely hold when accounting for stability is a testament to its effectiveness in explaining change in the constructs over time.

The current research also supports the importance including additional sources (i.e., parents' and peers') of autonomy support in the TCM. This is a little-researched additional

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prediction in the model, and findings are consistent with previous research incorporating sources of autonomy support as determinants in the model. As suggested by Hagger et al. (2009), this finding implies that other sources of autonomy support are also important in influencing adolescents' decision-making processes. Most important, however, is the fact that the original focus of the model, autonomy support from PE teachers in a separate context, still had pervasive influence on autonomous motivation for physical activities in leisure time, and beliefs and intentions toward, and actual participation in, physical activity in that context, even when including autonomy support from significant others and in a more proximal context. This is important for subsequent interventions because it means that interventions targeting promotion of autonomy support in PE will still have a pervasive effect on motivation, beliefs, and physical activity in leisure time, and points to a key context in which interventions may be effective. This is especially the case in the current research because it models change in the constructs over time, suggesting that change in autonomy support is related to change in motivation outside of school.

Contrary to TCM predictions, change in subjective norms did not predict the change in intention. Likewise, change in controlled motivation in leisure time and subjective norms did not mediate the relationship between change in controlled motivation in PE and change in intention. Previous studies have also indicated relatively small or no effects of subjective norms on intentions (Hagger et al., 2003; 2009; Hagger & Chatzisarantis, 2016; Hagger, Chatzisarantis, & Harris, 2006), suggesting a rather peripheral influence of subjective norms and controlled motivation in the model compared to autonomous motivation and attitudes and PBC (Hagger, Chatzisarantis, & Biddle, 2002). The relatively modest effects of subjective norms and controlled forms of motivation, highlights the importance of personal factors (attitudes and PBC) and

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autonomous motivation as determinants of physical activity, and highlights changes in these constructs as the key targets for potential interventions.

Regarding the prediction of physical activity participation, change in intentions and perceived behavioural control were the proximal determinants of physical activity change only for the model in which physical activity was measured by self-report and not by accelerometer-based devices. In addition, change in autonomous motivation in leisure time predicted physical activity through attitude, PBC and intention change consistent with the model's predictions. Taken together, these findings are consistent with previous tests of the model using conventional prospective designs without modelling change (Hagger & Chatzisarantis, 2012; 2016). These findings are directly comparable to these previous studies because measures used were identical, and demonstrates that model effects are supported when modelling change, which has important ramifications for those wishing to change behaviour.

However, the current study failed to demonstrate effects of change in intentions on outside of school physical activity measured using accelerometer-based devices. Current data are an important contribution to the literature given the preponderance of previous studies that have relied exclusively on self-report measures of physical activity, and there is a clear need for research adopting measures that do not rely on self-report and the inherent potential for recall errors and self-report bias associated with such measures. Current findings indicate small modest effects of intentions on self-reported physical activity behaviour, and seem to provide evidence to confirm that model effects do not hold up well in the face of measures that are ostensibly free from many of the biases associated with self-report behavioural measures. Coupled with the likely attenuation of effects as a result of accounting for stability over time through the use of residual change scores, current findings may raise questions over the value of the model constructs in determining physical activity behaviour.

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Of course, these data alone should not be used as a basis for rejecting the model entirely, but it certainly raises questions. In addition, there are measurement issues that may have influenced the results. For example, the lack of correspondence between the psychological constructs and the accelerometer-based device measure was a potential source of error. According to Ajzen (1991), it is important that measures of constructs like intentions and attitudes correspond closely with behavioural measures in terms of target (the individual performing the behaviour), the action (physical activity), the context (in leisure time), and time (five weeks). The self-report measure of physical activity used in the current study exhibited strong temporal correspondence with the psychological measures according to these criteria. In addition, the self-report measure of physical activity and psychological measures also had good correspondence in terms of the specific action and contexts of the behavior. Specifically, both measures made explicit reference to leisure-time physical activity, that is, physical activity performed outside of school and not, for example, in the course of active transport or incidental activities such as completing household chores. By contrast, the measure of accelerometer-based physical activity and the psychological measures exhibited problems with correspondence, which may have undermined prediction. For example, the accelerometer-based measure was only administered over a one-week census period, which is common practice due to the high cost and logistical challenge of collecting a large number of data points, but also meant that temporal correspondence with psychological measures, which referred to physical activity over a five week period, was compromised. In addition, the accelerometer-based measure encompassed incidental form of physical activity (e.g., active transport, household chores) in addition to leisure-time physical activity while the psychological variables made reference exclusively to leisure-time physical activity. This means that the psychological measures and accelerometer-



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based measure behavioral measure did not have optimal correspondence, as the accelerometer-based measure encompassed more types of activity.

Another possible reason for the small, non-significant relationship between intention and accelerometer-based physical activity may be due to ceiling effects on baseline and follow-up intention scores (i.e.,  $M = 5.90$  at baseline and  $M = 5.80$  at follow-up on a 7-point scale). The lack of variation in these scores over time suggests there was perhaps little variability in the intention change score over time, which may have placed limits on its capacity to account for variance in behavior. This could be attributed to methodological issues, such as too few items measuring the construct or a lack of sensitivity in the intention variable to account for true variation in intentions over time. A further option would be to adopt a more nuanced focus on intentions. For example, researchers have looked at other features of intentions as moderators of the intention-behavior relationship, such as the intention stability, certainty, and involvement (Cooke & Sheeran, 2004) and intentions to continue the behavior after achieving goals (Chatzisarantis et al., 2004; Chatzisarantis & Hagger, 2008), and examining such features may afford better prediction if adopted in future studies on the trans-contextual model.

From a practical standpoint, results of the current study suggest that the TCM can account for change in motivational and social cognition outcomes, and extends the predictive validity of the model. This suggests that affecting change in the motivational constructs, such as autonomous motivation in a PE context is related to change in autonomous motivation toward activities in an out-of-school context, and subsequent social cognition variables and intentions to perform physical activity in future. This implies that means that affect change in autonomous motivation in either context may be met by concomitant change in motivational and social cognition constructs in the model. Research has suggested that influential social agents such as physical education teachers, parents, and peers can adopt autonomy supportive behaviours to

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promote adolescents' autonomous motivation. Such behaviours may include providing choice and positive feedback, avoiding controlling language and contingencies, and showing interest. Intervening to encourage PE teachers, parents, and peers to adopt autonomy supportive behaviours frequently in their everyday interactions with their students about physical activity, children, or friends, respectively, is an important means to promote autonomous motivation and behaviour change with respect to physical activity in the relevant contexts. The current data provides stronger evidence to suggest that any external means that affects change in autonomous motivation could lead to change in associated variables. However, this should not imply causal effects and experimental or intervention studies are needed to confirm whether intervening to promote autonomy support leads to change in motivational and behavioural outcomes consistent with the change patterns observed here.

### **Strengths, Limitations, and Recommendations for Future Research**

The current study had numerous strengths: the adoption of a longitudinal design measuring the TCM constructs at two time points permitting the modelling of the stability of model constructs over time; the inclusion of multiple sources of perceived autonomy support including from teachers in a PE context, and parents and peers in a leisure time context in an extended version of the model; and the use of both self-report and non-self-report measures of physical activity permitting comparisons of effects across the different measures. Findings extend previous research by demonstrating that predictions of the model hold when accounting for stability. This suggests that the model is effective as a model of behaviour change over time. This suggests that change in constructs in the model is related to change in other constructs in the model (for example change in autonomous motivation in leisure time is related to change in attitudes and PBC, intentions, and, ultimately, self-reported physical activity). This has important ramifications for those designing behaviour change interventions based on the model. Previous

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research examining TCM effects without accounting for change does not provide a strong basis for the role of change, while the current findings suggest that changes in one construct may be accompanied by change in another. Of course, for this to be directly translatable to behaviour change interventions, such findings need to be verified experimentally. Findings also extend previous research by demonstrating model effects on changes in non-self-report physical activity. However, results using this measure raise questions over the capacity of the model to account for change in physical activity when such measures are used. However, this should be interpreted in light of issues of measurement correspondence.

Despite these strengths, a number of limitations should also be noted. First, other than the previously-mentioned issue of measurement correspondence between measures of study constructs and physical activity measured by accelerometer-based devices, there are also limitations of the accelerometer-based devices themselves. Accelerometer-based devices are not able to measure physical activity in certain contexts, for example if using a stationary bicycle, lifting weights, or swimming, which could lead to an underestimation of physical activity participation. As with all measures of physical activity, the accelerometer-based studies should be viewed as measure of physical activity that is free from bias or error.

A related issue is that self-reported questionnaires and accelerometer-based devices capture different physical activity-related constructs. Accelerometer-based devices measure all bodily movements whereas self-reported questionnaires quantify physical activity based on participants' recall of periods of time they engaged in defined types of activities for the specific period (Troiano et al., 2014). This means that the accelerometer-based measure did not distinguish between types of activity and captured energy expenditure in all activities performed during physical activity outside of school. In light of the differences between these measures, that we did not observe effects of intentions on the accelerometer-based measure should not be

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surprising, particularly given the likely lack of correspondence between the intention and activity measure. This also means that making direct comparisons between model results for the self-report and accelerometer-based devices should be made with caution as they do not capture the same physical activity-related constructs.

A further limitation is the problem associated with causal effects. While the current design permitted the modelling of change over time, it is important to note that these data are still correlational. As a consequence, any directional relationships should be considered as inferred from theory alone, not from the data. Optimal means to infer causality would be through an experimental or intervention design, examining effects of manipulating constructs such as perceived autonomy support or autonomous motivation, using appropriate behaviour change techniques (e.g., Gillison, Rouse, Standage, Sebire, & Ryan, 2019; Teixeira et al., 2020) on behavioural outcomes. Ultimately, in the current research, two time points were used to estimate change over time. However, future studies could use multiple time points to consistently evaluate change over time. We also acknowledge that we did not estimate the measurement error associated with the variables in the current model using a latent variable approach – the large numbers of constructs and parameters in the model meant that such an analytic approach was contraindicated. Replication of the current model in a large, representative sample which would permit a full latent variable approach is required.

There were also limitations related to the study measures. In order to reduce the response burden for participants, we used two-item scales to measure the social cognition constructs in the TCM. While use of two-item scales is considered sub-optimal, previous research has revealed that the items used in the present study adequately indicate latent factors of model constructs alongside other items, indicating strong good inter-item correlations (e.g., Hagger & Chatzisarantis, 2005). These results suggest that adoption of scales with a greater number of

items would not have led to a further reduction in the measurement error in these constructs.

Nevertheless, it would be important for future research to replicate current findings using latent variables for each construct indicated by a greater number of items.

In addition, we did not include measures of additional motivation-related constructs from self-determination theory, including amotivation and integrated regulation. Amotivation reflects a lack of intention or reasons for performing a behaviour or task, and integrated regulation is an autonomous form of motivation that reflects full internalization and integration of behaviours or tasks consistent with the individual's genuine sense of self. Research suggests that integrated regulation is less relevant in younger populations as it takes a while for people to integrate behaviours and tasks into their sense of self (Deci & Ryan, 2000; Vallerand, 1997). Furthermore, even though individual studies have provided support for the discriminant validity of scales tapping integrated regulation (e.g., McLachlan et al., 2011), a recent meta-analysis of self-determination theory measures raised serious questions over the discriminant validity of currently available integrated measures of integrated regulation (Howard et al., 2017). In addition, amotivation strictly speaking lies outside the continuum of motivation expressed in self-determination theory, so would not be included as a measure of relative autonomy. Nevertheless, future research may consider including measures of these constructs and testing whether they have unique influences on physical activity motivation, intentions, and behaviour alongside existing TCM constructs, provided measures with adequate validity can be identified.

### **Conclusions**

The current research advanced knowledge by testing the premises of the TCM using a unique design that accounted for change in constructs over time. The longitudinal design and use of residual change scores enabled evaluation of whether the model is effective in accounting for change in motivational outcomes and leisure time physical activity behaviour over time.

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Findings supported key predictions of the model, including the trans-contextual effects and prediction of change in leisure time physical activity intentions. Findings also demonstrate the importance of change in perceived autonomy support from peers and parents to the prediction of change in autonomous motivation toward, and actual participation in, leisure time physical activity. However, findings also raised questions over the predictive validity of the model when accelerometer-based devices were used as a measure of physical activity participation, although the lack of correspondence in the TCM measures and the accelerometer-based device measure is an issue with limited drawing definitive conclusions. The examination of change in the model is important if such data is to be used as basic research to inform the development of interventions. Although the inference of causality cannot be made from these data, demonstration of links between constructs when accounting for change highlights the potential for changes in constructs like autonomous motivation to coincide with change in outcomes such as intentions and physical activity participation. However, future research verifying these patterns of effects experimentally or using interventions is important.

### **Declaration of Interest Statement**

No potential conflict of interest was reported by the authors.

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**Table 1.** Summary of the hypothesized direct and indirect effects in the trans-contextual model for physical education and leisure time physical activity.

H	Independent variable	Dependent variable	Mediator(s)
<b>Direct effects</b>			
H <sub>1</sub>	PAS (PE teacher)	Aut. mot. (PE)	-
H <sub>2</sub>	Aut. mot. (PE)	Aut. mot. (leisure time)	-
H <sub>3</sub>	Con. mot. (PE)	Con. mot. (leisure time)	-
H <sub>4</sub>	PAS (parent/peer)	Aut. mot. (leisure time)	-
H <sub>5</sub>	Aut. mot. (leisure time)	Attitude	-
H <sub>6</sub>	Aut. mot. (leisure time)	PBC	-
H <sub>7</sub>	Con. mot. (leisure time)	Subjective norm	-
H <sub>8</sub>	Attitude	Intention	-
H <sub>9</sub>	Subjective norm	Intention	-
H <sub>10</sub>	PBC	Intention	-
H <sub>11</sub>	Intention	MVPA/Self-reported PA	-
H <sub>12</sub>	PBC	MVPA/Self-reported PA	-
<b>Indirect effects</b>			
H <sub>13</sub>	PAS (PE teacher)	Aut. mot. (leisure time)	Aut. mot. (PE)
H <sub>14</sub>	PAS (parent/peer)	Attitude	Aut. mot. (leisure time)
H <sub>15</sub>	PAS (parent/peer)	PBC	Aut. mot. (leisure time)
H <sub>16</sub>	Aut. mot. (PE)	Intention	Aut. mot. (leisure time) Attitude
H <sub>17</sub>	Aut. mot. (PE)	Intention	Aut. mot. (leisure time) PBC
H <sub>18</sub>	Con. mot. (PE)	Intention	Con. mot. (leisure time) Subjective norm
H <sub>19</sub>	Aut. mot. (leisure time)	Intention	Attitude
H <sub>20</sub>	Aut. mot. (leisure time)	Intention	PBC
H <sub>21</sub>	Con. mot. (leisure time)	Intention	Subjective norm
H <sub>22</sub>	Aut. mot. (leisure time)	MVPA/Self-reported PA	Attitude Intention
H <sub>23</sub>	Aut. mot. (leisure time)	MVPA/Self-reported PA	PBC Intention
H <sub>24</sub>	Con. mot. (leisure time)	MVPA/Self-reported PA	Subjective norm Intention
H <sub>25</sub>	Attitude	MVPA/Self-reported PA	Intention
H <sub>26</sub>	PBC	MVPA/Self-reported PA	Intention
<b>Total effects</b>			
H <sub>27</sub>	PAS (PE teacher)	Intention	
H <sub>28</sub>	PAS (PE teacher)	MVPA/Self-reported PA	

*Note.* H = hypothesis; PAS = perceived autonomy support; PE = physical education context; Aut.mot = autonomous motivation; Con.mot = controlled motivation; leisure time = leisure time context; PBC = perceived behavioural control; MVPA = objectively measured moderate-to-vigorous physical activity; PA = physical activity.

**Table 2.** Zero-order intercorrelations and descriptive statistics for residual change scores, and scale reliabilities for study variables at each time point.

Variable	Correlation													
	1	2	3	4	5	6	7	8	9	10	11	12	13	
1. PAS (PE teacher)														
2. PAS (Parent)	.22**													
3. PAS (Peer)	.28***	.34***												
4. Aut. mot. (PE)	.26***	.06**	.07***											
5. Aut. mot. (leisure time)	.20***	.40***	.30***	.32***										
6. Con. mot. (PE)	.00	.00	.00	.11*	.03									
7. Con. mot. (leisure time)	.00	.00	.00	.05*	.21***	.40***								
8. Attitude	.07***	.15***	.11***	.12***	.37***	.01*	.08***							
9. Subjective norms	.00	.00	.00	.02*	.07***	.13***	.33***	.14**						
10. PBC	.06***	.13***	.10***	.10***	.33***	.01*	.07***	.42***	.06					
11. Intention	.08	.10***	.08***	.12***	.25***	.00	.06**	.47***	.09	.51***				
12. Leisure time MVPA	.00	.00	.04	.01	.00	.00	.00	-.01	.00	.02	-.04			
13. Self-reported PA	.00	.04*	.02	-.01	.09***	.00	.02**	.14***	.02	.27***	.23***	N/A		
Reliability at Time 1	.78	.83	.86	.80	.88	.67	.72	.85	.65	.72	.90	N/A	.84	
Reliability at Time 2/3	.84	.87	.86	.85	.89	.65	.74	.87	.66	.77	.91	N/A	.89 <sup>a</sup>	

*Note.*  $N = 331$ . Leisure time MVPA was calculated in min/day. <sup>a</sup>Reliability coefficient for self-reported PA was calculated at Time 3. All the study variables are residual change scores. Reliability coefficients for scales comprising three items or more are alpha coefficients ( $\alpha$ ; Cronbach, 1951); Reliability coefficients for scales comprising two items are the Spearman-Brown coefficient. PAS = Perceived autonomy support; Aut. mot = autonomous motivation; Con. mot. = Controlled motivation; PE = Physical education; PBC = Perceived behavioural control; Leisure time = Leisure time context; MVPA = Moderate-to-vigorous physical activity measured by accelerometer-based devices. \* $p < .05$ , \*\* $p < .01$ , \*\*\* $p < .001$ .



**Table 3.** Standardized ( $\beta$ ) and unstandardized ( $B$ ) parameter estimates for the direct and indirect effects from the path analysis of the trans-contextual model using residual change scores.

H	Independent variable	Dependent variable	Mediator(s)	$\beta$	$B$	95% CI <sub>BC</sub>	
						LL	UL
<b>Direct effects</b>							
H <sub>1</sub>	PAS (PE teacher)	Aut. mot. (PE)	-	.26***	0.26***	0.16	0.36
H <sub>2</sub>	Aut. mot. (PE)	Aut. mot. (LT)	-	.29***	0.26***	0.18	0.34
H <sub>3</sub>	Con. mot. (PE)	Con. mot. (LT)	-	.40***	0.41***	0.30	0.52
H <sub>4</sub>	PAS (parent)	Aut. mot. (LT)	-	.32***	0.32***	0.20	0.42
	PAS (peer)			.16**	0.12***	0.05	0.19
H <sub>5</sub>	Aut. mot. (LT)	Attitude	-	.37***	0.40***	0.26	0.53
H <sub>6</sub>	Aut. mot. (LT)	PBC	-	.33***	0.38***	0.27	0.50
H <sub>7</sub>	Con. mot. (LT)	Subjective norm	-	.33***	0.36***	0.28	0.46
H <sub>8</sub>	Attitude	Intention	-	.30***	0.32***	0.22	0.44
H <sub>9</sub>	Subjective norm	Intention	-	.03	0.02	-0.04	0.09
H <sub>10</sub>	PBC	Intention	-	.38***	0.37***	0.26	0.47
H <sub>11</sub>	Intention	Self-reported PA	-	.14*	0.13*	0.04	0.22
		MVPA	-	-.07	-1.28	-3.41	0.99
H <sub>12</sub>	PBC	MVPA	-	.05	0.97	-1.55	3.45
		Self-reported PA	-	.20**	0.19**	0.08	0.29
<b>Indirect effects</b>							
H <sub>13</sub>	PAS (PE teacher)	Aut. mot. (LT)	Aut. mot. (PE)	.07***	0.07***	0.03	0.11
H <sub>14</sub>	PAS (parent)	Attitude	Aut. mot. (LT)	.12***	0.13***	0.06	0.19
	PAS (peer)			.06**	0.05**	0.02	0.09
H <sub>15</sub>	PAS (parent)	PBC	Aut. mot. (LT)	.11***	0.12***	0.07	0.17
	PAS (peer)			.05**	0.04**	0.02	0.08
H <sub>16</sub>	Aut. mot. (PE)	Intention	Aut. mot. (LT)	.03***	0.03***	0.02	0.06
H <sub>17</sub>	Aut. mot. (PE)	Intention	Attitude	.04***	0.04***	0.02	0.05
			PBC				
H <sub>18</sub>	Con. mot. (PE)	Intention	Con. mot. (LT)	.00	0.00	-0.01	0.01
			Subjective norm				

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H <sub>19</sub>	Aut. mot. (LT)	Intention	Attitude	.11***	0.13***	0.07	0.20
H <sub>20</sub>	Aut. mot. (LT)	Intention	PBC	.13***	0.14***	0.09	0.21
H <sub>21</sub>	Con. mot. (LT)	Intention	Subjective norm	.00	0.01	-0.01	0.03
H <sub>22</sub>	Aut. mot. (LT)	MVPA	Attitude	-.01	-0.16	-0.56	0.07
		Self-reported PA	Intention	.02**	0.13**	0.07	0.20
H <sub>23</sub>	Aut. mot. (LT)	MVPA	PBC	-.01	-0.18	-0.51	0.09
		Self-reported PA	Intention	.02**	0.14**	0.09	0.21
H <sub>24</sub>	Con. mot. (LT)	MVPA	Subjective norm	-.01	-0.00	-0.01	0.00
		Self-reported PA	Intention	.00	0.00	-0.00	0.01
H <sub>25</sub>	Attitude	MVPA	Intention	-.02	-0.41	-1.26	0.23
		Self-reported PA		.04*	0.04*	0.01	0.08
H <sub>26</sub>	PBC	MVPA	Intention	-.03	-0.47	-1.29	0.25
		Self-reported PA		.08*	0.05*	0.02	0.08
<b>Total effects</b>							
H <sub>27</sub>	PAS (PE teacher)	Intention		.06	0.06	-0.02	0.13
H <sub>28</sub>	PAS (PE teacher)	MVPA		-.00	-0.04	-1.72	1.69
		Self-reported PA		-.01	-0.01	-0.10	0.07

Note.  $N = 331$ . H = Hypothesis; CI = Confidence intervals of parameter estimates; LL = Lower limit of 95% CI; UL = Upper limit of 95% CI; PAS = Perceived autonomy support; PE = Physical education Aut. mot = Autonomous motivation; Con. mot = Controlled motivation; SN = Subjective norm; PBC = perceived behavioural control; Leisure time = Leisure time context; MVPA = Moderate-to-vigorous physical activity measured using accelerometer-based devices.

\* $p < .05$ , \*\* $p < .01$ , \*\*\* $p < .001$ .

# Trans-contextual model and physical activity

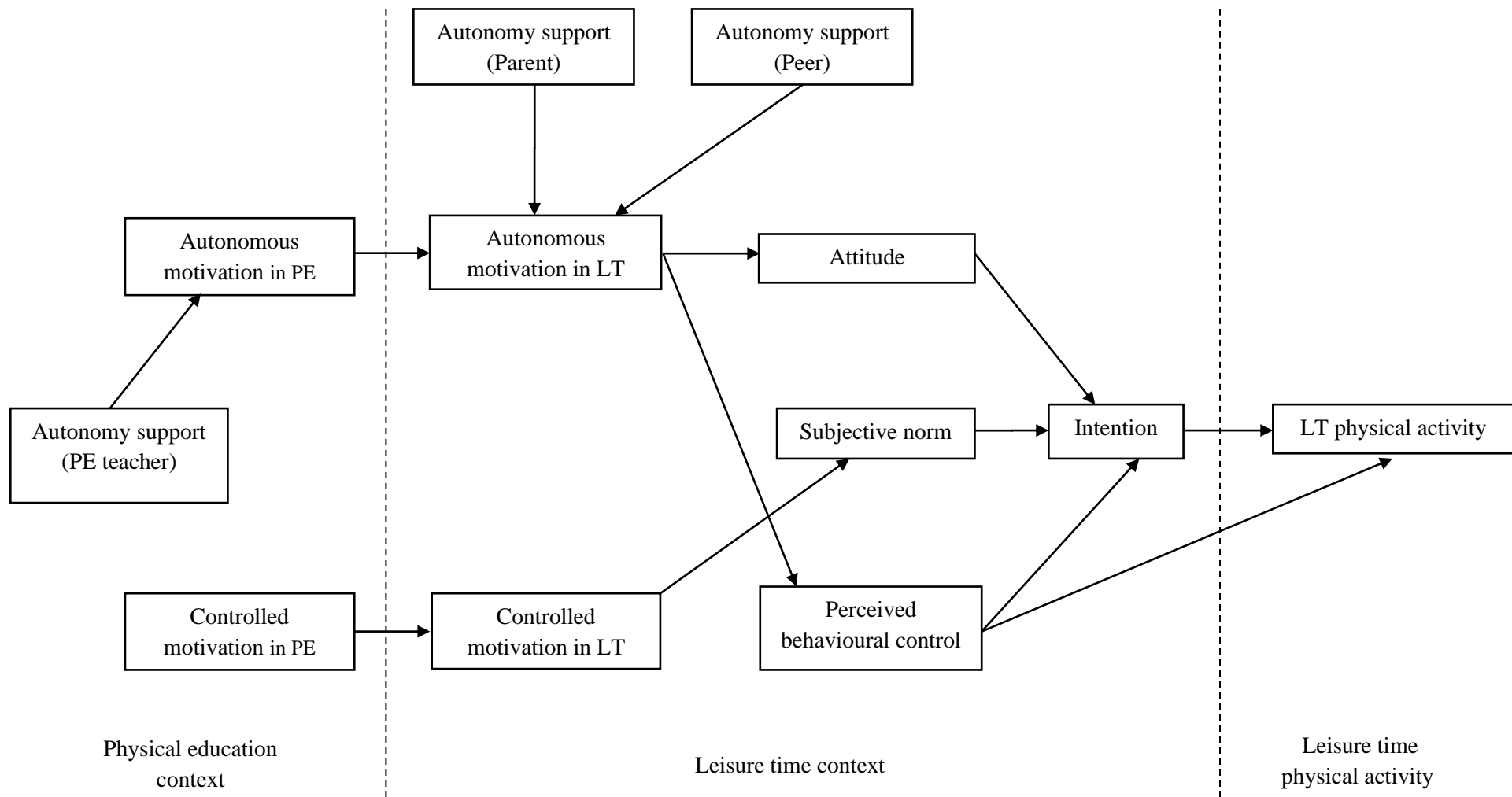
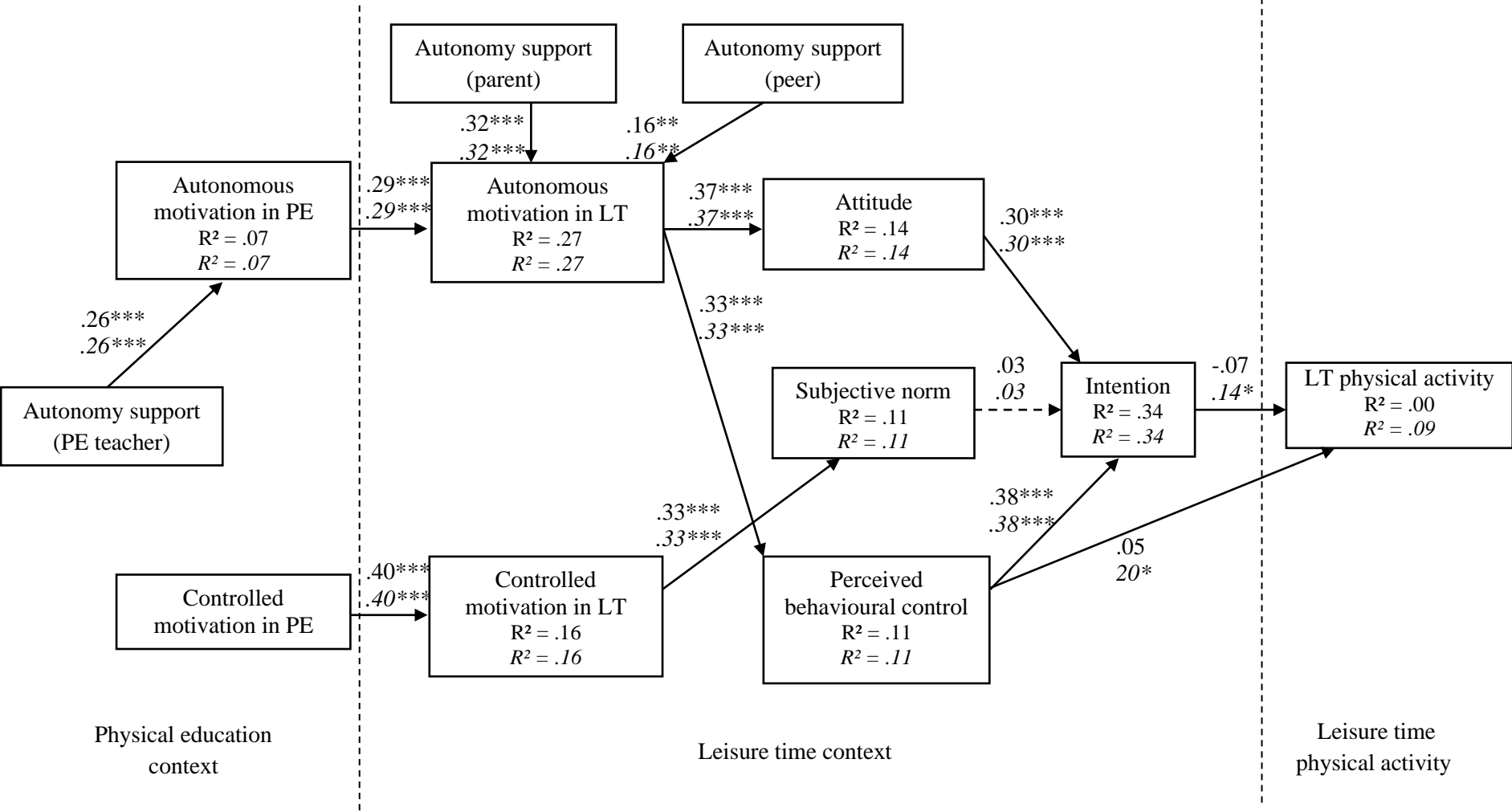


Figure 1. Hypothetical model of the trans-contextual model. Solid lines indicate direct effects between the study variables. PE = physical education, LT = leisure-time.

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## Trans-contextual model and physical activity

*Figure 2.* Results of a path analysis testing trans-contextual model predictions for leisure time moderate-to-vigorous physical activity measured by accelerometer-based devices and self-reports.

*Note.* All variables were residual change scores. Change scores for all study variables were calculated by regressing the score of each variable measured at Time 2 on its score measured at Time 1, with the exception of the leisure-time physical activity variable for which the Time 3 score was regressed on Time 1 score. Upper values for the path and  $R^2$  coefficients are for physical activity measured by accelerometer-based devices and the lower line in italics are for physical activity measured by self-report. For clarity, the error covariances among the attitude, subjective norm, and perceived behavioural control (PBC) constructs, the perceived autonomy support constructs, and motivational constructs have been omitted. PE = Physical education context; LT = Leisure-time context. \* $p < .05$ , \*\* $p < .01$ , \*\*\* $p < .001$ . Full results including covariance matrices are available online at [https://osf.io/9xhe5/?view\\_only=acb04558e250424184fbb6badffdfc27](https://osf.io/9xhe5/?view_only=acb04558e250424184fbb6badffdfc27).