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Trans-Contextual Model Predicting Change in Out-of-School Physical Activity: A One-Year Longitudinal Study

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A One-Year Longitudinal Study of the Trans-Contextual Model

Abstract

The aim of the current study was to test the long-term predictive validity of the trans-contextual model in accounting for variance in adolescents' out-of-school physical activity measured by self-report and accelerometer based-devices over a one-year period. Secondary school students (*N* = 265) aged 11 to 15 years completed a three-wave survey on two occasions in time, spanning a one-year interval, measuring perceived autonomy support in physical education (PE), peer and parent autonomy support in leisure-time, autonomous and controlled motivation in PE and leisure-time, attitude, subjective norms, perceived behavioural control, intention, and out-of-school physical activity both by self-report and accelerometer-based devices. A variance-based structural equation model using residualized change scores revealed that perceived autonomy support from PE teachers predicted autonomous motivation in PE, and autonomous motivation in PE predicted autonomous motivation in leisure-time. In addition, peer and parent autonomy support predicted autonomous motivation in leisure-time. Autonomous motivation in leisure-time indirectly predicted physical activity intention mediated by attitude and perceived behavioural control. Intention predicted self-reported physical activity participation, although the effect was in the opposite direction to our prediction, but not physical activity measured by accelerometer-based devices. Results support some tenets of the trans-contextual model over a one-year time period, particularly the determinants of physical activity intentions. The introduction of COVID-19 restrictions may explain the negative relationship between intention and self-reported physical activity. Further longitudinal studies are needed to verify the results of the current study.

Key words: physical education, trans-contextual model of motivation, out-of-school physical activity, accelerometer, longitudinal study, self-report.

Introduction

Regular physical activity (PA) participation is associated with adaptive psychological, cognitive, and physical health outcomes in young populations (Poitras et al., 2016). Studies have indicated marked decreases in levels of PA participation during the transition from childhood to adolescence (Chong et al., 2020). The promotion of PA in early adolescents, therefore, has been identified as an important public health priority in many nations (Guthold et al., 2018). Promoting PA participation in young people necessitates an understanding of the potentially modifiable determinants of PA behaviour in this population that could potentially serve as targets in behavioural interventions (Hagger and Hamilton, 2019). Behavioural scientists, particularly those in psychology, have, therefore, aimed to identify such determinants and the processes by which they relate to behaviour to provide formative evidence to develop behavioural interventions. Central to this goal has been the application of motivational and social cognition theories, which have been extensively applied to predict health behaviour in many contexts and populations, and have also been identified as targets for intervention (Hagger et al., 2020).

At the forefront of research examining the determinants of PA in young people has been the trans-contextual model (TCM; Hagger and Chatzisarantis, 2012, 2016). The model is an integrated approach to identify the psychological determinants of young people's PA participation, with a key focus on determinants in two contexts: physical education (PE) and leisure-time PA. The premise behind this is that determinants in these two contexts are likely to be highly salient in determining children's intentions and participation in PA. The model specifies the mechanisms by which students' perceptions of autonomy support from PE teachers relate to their motivation toward, and actual participation in, PA in a leisure-time context (Hagger et al., 2003). While the model has demonstrated broad support for its key hypotheses, most studies applying the model to date have used prospective designs and predicted PA behaviour over relatively brief periods. Few studies have

used a longitudinal design in which model constructs have been measured at multiple points in time allowing for the modelling of change (Hutmacher et al., 2020), and even fewer have examined long-range prediction beyond a few weeks (Hagger and Chatzisarantis, 2016). In addition, there is a lack of research applying the model that has adopted non-self-report measures of PA, such as accelerometers (Hagger and Chatzisarantis, 2016).

Longitudinal tests of the trans-contextual model

The TCM is based on the integration of self-determination theory (Deci and Ryan, 1985), the theory of planned behaviour (Ajzen, 1991), and Vallerand's hierarchical model of motivation (Vallerand, 1997). The model proposes three core premises (Hagger et al., 2003). First, students' perceptions of autonomy support from their PE teachers are proposed to be related to their autonomous motivation toward activities performed in PE. A few TCM-based studies have shown that the satisfaction of basic psychological needs in PE may serve as determinants of autonomous motivation and beliefs toward leisure-time physical activity participation, and there may be trans-contextual effects of need satisfaction in parallel with forms of motivation (Barkoukis et al. 2010; Gonzales-Cutre et al., 2014). Second, autonomous motivation in PE is proposed to relate to autonomous motivation toward similar activities in the leisure-time context. Third, autonomous motivation in the leisure-time context is proposed to be related to students' future intentions to participate in those activities.

Previous studies applying the TCM have generally adopted correlational, prospective designs in which model constructs are measured at an initial point in time and PA measured at a subsequent point in time. These studies have lent general support to the core model premises (Hagger and Chatzisarantis, 2012, 2016). However, recent studies (Kalajas-Tilga et al., 2021; Polet et al., 2020) have provided additional support for some of the TCM premises by adopting a study design that enabled modelling of change in the TCM constructs and PA behaviour over time using residualized

change scores. The residualized change score approach accounts for the stability (change) in study constructs across several time points taking into account the naturally occurring change in constructs over time (Rowan et al., 2017). This approach enables researchers to account for dynamic changes in motivational and social cognition constructs in determining out-of-school PA over time, and has advantages over the relatively static approach adopted in previous prospective tests of the TCM. The value of the residual change score approach is that researchers can make stronger claims concerning the value of the model in accounting for change in study constructs over time by controlling for the effect of each model construct on itself over time. This eschews typical approaches to model testing which rely on measures taken at single points in time and, therefore, cannot account for the likely change in constructs over time with the advent of new information, changing environments, and so on.

Studies adopting the change score approach have demonstrated the efficacy of the model in predicting change in students' autonomous motivation in PE and leisure-time by change in perceived autonomy support from PE teachers, and change in intentions and participation in self-reported leisure-time PA (Kalajas-Tilga et al., 2021; Polet et al., 2020). However, the study by Kalajas-Tilga et al. (2021) found no effects of change in intention on change in out-of-school PA measured by accelerometer-based devices. These findings raised some questions regarding the predictive validity of the model when using non-self-report measures, with one possibility that the effects may be due to better correspondence between measures of the constructs and self-report measures of PA. However, these findings are from one study and do not represent converging evidence from consistent tests of the model comparing self-report and non-self-report measures of PA.

In addition, there is a relative dearth of research on the long-range predictive validity of the TCM beyond a few weeks. However, some longitudinal studies of the key theories on which the TCM is based, have been informative of the potential for long-range effects of its key premises. For

example, researchers have demonstrated that the relationship between intentions and PA behaviour remains statistically significant over longer periods of up to 12 months (e.g. Raudsepp et al., 2010). This is also consistent with meta-analytic data demonstrating that the intention-behavior relationship is consistent in studies with a long time lag between intention and behavior measures (Hagger et al., 2018; McEachan et al., 2011). Studies adopting panel designs have demonstrated longitudinal effects of model premises over time as well as enabling inferences regarding the directional effects among the study constructs. For example, a cross-lagged panel study based on the integration of self-determination theory and the theory of planned behaviour, indicated that autonomous motivation predicted subsequent social cognition constructs and intentions from the theory of planned behaviour, supporting this key relationship within the model in a sport injury context (Chan et al., 2020). A recent study adopting a panel design found significant reciprocal relationships between autonomous motivation in PE and leisure-time autonomous motivation over six-months period (Hutmacher et al., 2020). So, research adopting such designs to test long-range prediction will provide more robust, reliable data on its long-range predictive validity and its capacity to account for change among its constructs over time.

The present study

To our knowledge no research to date has tested the TCM premises in a longitudinal design over an extended period. A primary objective of the present study was to use residualized change scores within the TCM to test the proposed relationships among model constructs over a one-year period. In addition, only one TCM-based study (Kalajas-Tilga et al., 2021) so far has adopted a non-self-report measure of PA participation. Using the device-based measurement of PA allows more objective assessment of PA compared to self-reported measures that have been shown to be subject to different biases (Adams et al., 2005). Therefore, researchers have proposed that to be more precise and reduce bias while investigating the behavioural outcomes within the TCM, studies should try not

to rely only on self-report measures (Hagger et al., 2005). The current study aimed to address this dearth of research by testing the TCM over a one-year time period using accelerometer-based devices to measure out-of-school PA alongside self-report physical activity measures.

Based on previous research on the TCM model we hypothesize that change in perceived autonomy support from PE teachers is expected to predict change in students' autonomous motivation in PE over a one-year period (H_1), and changes in autonomous and controlled motivation in PE are expected to predict changes in autonomous (H_2) and controlled (H_3) motivation with respect to out-of-school PA over a one-year period. Change in perceived autonomy support from parents and peers is expected to predict change in autonomous motivation in a leisure-time context over a one-year period (H_4). Change in autonomous motivation in a leisure-time context is expected to predict changes in attitudes (H_5) and perceived behavioural control (PBC; H_6) toward out-of-school PA, and change in controlled motivation is expected to predict change in subjective norms (H_7) toward PA in the same context, over a one-year period. Changes in attitudes (H_8), subjective norm (H_9), and PBC (H_{10}) are expected to predict changes in leisure-time PA intentions, and changes in intentions (H_{11}) and PBC (H_{12}) are expected to predict change in out-of-school PA over a one-year period.

These direct effects imply a series of theoretically-consistent indirect effects. Specifically, we expected indirect effects of change in perceived autonomy support from PE teachers on changes in autonomous motivation toward out-of-school PA mediated by change in autonomous motivation in PE (H_{13}), and indirect effects of changes in parents' and peers' autonomy support on changes in attitudes (H_{14}) and PBC (H_{15}), respectively, mediated by change in autonomous motivation in leisure-time over a one-year period. Change in autonomous motivation in PE was expected to predict change in intention toward out-of-school PA mediated by change in autonomous motivation, attitudes, and PBC (H_{16}) in leisure-time over a one-year period. Change in controlled motivation in

PE was expected to predict change in intention mediated by change in controlled motivation and subjective norms (H_{17}) in leisure-time over a one-year period. Change in autonomous motivation in leisure-time was expected to predict change in intention mediated by change in attitude and PBC (H_{18}). Change in controlled motivation in leisure-time was expected to predict change in intention mediated by change in subjective norm (H_{19}). Change in autonomous motivation in leisure-time was expected to predict change in PA behaviour mediated by change in intentions, attitude, and PBC (H_{20}) in leisure-time, and change in controlled motivation in leisure-time was expected to predict change in PA behaviour mediated by change in intention and subjective norm (H_{21}) in the same context, over a one-year period. Change in attitude (H_{22}) and PBC (H_{23}) was expected to predict change in out-of-school PA mediated by change in intention over a one-year period. Finally, we expected total effects of change in perceived autonomy support in PE on change in intention (H_{24}) and out-of-school PA (H_{25}) mediated by the 'motivational sequence' in the model over a one-year period.

Method

Participants and design

Secondary school students (N = 351, male, n = 105, female, n = 246; M_{age} = 13.1 years, SD = .96, range 11-15) from 16 Estonian public schools participated in the study. The sample consisted entirely of white people. All participants were from the same ethnic group with similar socio-economic status. In addition, PE classes in the schools were compulsory, with a frequency of two times per week, and each lesson lasted for 45 minutes. The study adopted a two-occasion longitudinal design with three waves of data collected within each occasion, a total of six waves of data collection[1]. Each occasion was separated by one year and each wave was separated by five

[1] The results of the first occasion data collection are recently published by Kalajas-Tilga et al., 2021. The current study adds three additional waves of data collection one year later.

weeks. On each occasion, participating students completed measures of psychological constructs (e.g. perceived autonomy support from their PE teacher, peers and parents, autonomous and controlled motivation in PE and leisure-time, attitudes, subjective norms, PBC, intention, and self-reported PA) at waves one and two. Accelerometer-based PA was measured for seven days following waves one and three on the first occasion and once following wave three on the second occasion. The measures of the psychological constructs were taken at the first and second waves of data collection on both occasions to allow the modelling of change in study constructs. The study design is depicted in Appendix A.

The University research ethics committee and school administrators approved the study prior to data collection. Informed consent forms were provided for all eligible students. Students were eligible if they were grade six to eight students without any physical restrictions for participating in the PE classes. All eligible students and their parents gave written informed consent for participation in the study. The students were given verbal instructions on how to complete the questionnaires, and on how to use the accelerometers, by the research assistants. The questionnaires were completed in quiet classroom conditions in the presence of a research assistant. The average time for giving instructions and completing the questionnaires was about 15 to 20 minutes. Questionnaires were completed anonymously and matched using an individual code with numbers and letters based on participants' initials, birth date, gender, class, and accelerometer number. The participants completed data collection for the first occasion in the period from October 2017 to May 2019 and the second data collection occasion within the period from November 2018 to May 2020.

Measures

The participants responded to measures of the TCM constructs including perceived autonomy support, autonomous motivation, and constructs from the theory of planned behaviour on seven-point scales ranging from one (*strongly disagree*) to seven (*strongly agree*).

Perceived autonomy support

Perceived autonomy support from the students' PE teachers, peers and parents was measured using items from the Perceived Autonomy Support Scale for Exercise Settings (PASSES; Hagger et al., 2007). Perceptions of autonomy-supportive behaviour for each salient social agent (i.e. PE teacher's, peer's and parents' autonomy support) was measured by four items (e.g. "I feel that my [salient social agent(s)] provides 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 and it has been previously used in an Estonian context (e.g. Hagger et al., 2007; 2009; Kalajas-Tilga et al., 2021).

Autonomous and controlled motivation towards physical education

An adapted version of the perceived locus of causality questionnaire (Goudas et al., 1994) was used to measure participants' autonomous and controlled forms of motivation toward PE. Each subscale consisted of two items. Participants were presented with a common stem: "I do PE…". The stem was followed by sets of items measuring autonomous motivation subscales: 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. Previous studies have shown the questionnaire to be a valid and reliable measure (e.g. Standage et al., 2012), and it has previously been used in an Estonian context (Koka, 2013; Koka et al., 2020).

Leisure-time autonomous and controlled motivation

An adapted version of Ryan and Connell's (1989) measure of perceived locus of causality for leisure-time was used to measure participants' autonomous and controlled motivation during leisure-time. Each subscale consisted of two items for each autonomous motivation regulation style. Participants were presented with a common stem: "I do PA during my free time…". The stem was followed by items for the intrinsic motivation (e.g. "…because I enjoy doing PA"), identified regulation (e.g. "…because I value the benefits of PA"), introjected regulation (e.g. "…because I feel bad about myself if I don't do PA"), and external regulation (e.g. "…because I feel under pressure from people I know to do PA") subscales. The autonomous motivation construct was indicated by calculating the average of scores on the intrinsic motivation and identified regulation subscale items, and controlled motivation construct was indicated by calculating the average of scores on the items for the introjected regulation and external regulation subscales. The perceived locus of causality questionnaire has shown to be a valid and reliable measure (e.g. Hagger et al., 2005; Polet et al., 2020), and it has previously been used in an Estonian context (Koka et al., 2020).

Theory of planned behaviour constructs

Measures of the theory of planned behaviour constructs were developed based on guidelines provided 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 five weeks"). Attitude was measured using three seven-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 five weeks is …". Subjective norms were measured by two items (e.g. "Most people close to me expect me to do active sports and/or vigorous physical activities during my leisure time for the next five weeks"). PBC was measured by 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 five weeks"). The measures of the

constructs of the theory of planned behaviour have shown to be valid and reliable for use with school children, and they have previously been used in an Estonian context (e.g. Hagger et al., 2009; Kalajas-Tilga et al., 2021; Koka et al., 2020; Pihu et al., 2008).

Accelerometer-based physical activity

Actigraph GT3X (ActiGraph LLC, Pensacola, FL, USA) accelerometers were used to measure participants' out-of-school moderate-to-vigorous PA at the first data collection occasion (waves one and three) and the second data collection occasion (wave three). Residual change scores for participants' PA measured across the waves of the first data collection occasion was considered as participants' past behaviour. Participants were asked to wear the device on their waist for seven consecutive days. The accelerometer could only be removed during water-based activities and sleeping. Moderate-to-vigorous PA in out-of-school time consisted of all sports and other vigorous activities participants performed outside of school hours. In the current study, the sampling interval was set at 15s. Accelerometer data were considered valid if over 600 min (10 hours) of data were recorded per day with data for least four days out of seven present. Zero activity counts of consecutive 60 min were classified as non-wear time. The moderate-to-vigorous PA level in accelerometers was measured using recommended cut-off points (i.e. ≥ 2296 counts/min) developed by Evenson et al. (2008).

Self-reported physical activity

Self-reported PA during leisure-time was assessed in all waves and at both data collection occasions using an adapted version of Godin and Shepherd's (1985) leisure-time exercise questionnaire. Participants responded to 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 six-point scale (one = *never* and six = *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 six-point scale (one = *not at all* and six = *most days per week*). The measure of leisure time self-reported physical activity has shown to be valid and reliable (Hagger et al., 2003, 2005, 2009; Polet et al., 2020), and has previously been used in an Estonian context (Hein et al., 2020; Tilga et al., 2020).

Data analysis

Descriptive data was analyzed using the SPSS Statistics 23 (IBM Corp., Armonk, NY, USA) software. The proposed model was tested using variance-based structural equation modelling (VB-SEM), also known as partial least squares (PLS) analysis, using the Warp PLS v7.0 software (Kock, 2020). VB-SEM is a distribution-free analytic method which has been shown in simulation studies to be less affected by model complexity, non-normality, and smaller sample sizes (Henseler et al., 2009). Missing data was imputed using arithmetic mean imputation, which simulation studies have shown to be the most effective in producing stable model estimates in simulation studies applying the PLS method (Kock, 2020). Examination of skewness and kurtosis estimates (range = -7 to +7) was used to evaluate the extent to which study items approached normality. Values between -2 and +2 and between -7 and +7 are considered acceptable for skewness and kurtosis estimates, respectively (Byrne, 2010).

In the main analysis two models were analyzed – one with self-reported PA as the dependent variable (Model 1), and the other with accelerometer-based PA as the dependent variable (Model 2). In addition, as part of the study period fell in the spring of 2020 with very strict COVID-19 restrictions some of the participants (n = 129) could not wear the accelerometers for the third wave of the second data collection occasion, and the only available option was to complete self-report measures. Therefore, we performed an auxiliary analysis of the models with self-reported PA as the

dependent variable on participants whose completion of the study was not affected by the restrictions (n = 136).

To account for change in data across waves and data collection occasions, we computed residual change scores for each model variable. Residual change scores for the psychological constructs were calculated by regressing scores for each construct measured at wave two on scores measured at wave one for each data collection occasion. Accelerometer-based PA residualized change scores were calculated by regressing scores from accelerometer measurements taken at wave three of the second data collection occasion on accelerometer measure score taken at waves one and three on the first occasion. Self-reported PA residual change scores were calculated in a similar manner by regressing PA scores for measures taken at the third wave on the second occasion on measures taken at all previous waves and occasions (i.e. five prior measures). The effects of age and gender were controlled for by including these variables as covariates when computing the residual change scores 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 wave scores.

Prior to the main analysis we conducted discriminant validity in internal consistency checks for model variables. Discriminant validity of constructs was confirmed if the square root of the AVE for each latent variable in the VB-SEM model exceeded its correlation coefficient with other latent variables[2]. Internal consistency was evaluated using alpha reliability coefficients with values of 0.70 or above considered acceptable (Cronbach, 1951). The overall fit of the proposed models in the VB-

[2]It is important to note that this approach to discriminant validity has been criticized, and an alternative has been suggested based on a heterotrait-monotrait ratio of correlations (Henseler et al., 2015). However, this alternative was contraindicated in the current analysis as the latent variables comprised single-item indicators derived from the residual change scores, and this should be recognized as a limitation. However, a common sense perusal of the size of the correlations in the matrix of correlations among the latent variables makes clear that there are unlikely to be problems with discriminant validity.

SEM analyses was evaluated using multiple criteria: the goodness-of-fit (GoF) index with values of .100, .250, and .360 corresponding to small, medium, and large effect sizes, respectively (Tenenhaus et al., 2005), the average variance inflation factor (AVIF) value for model parameters which is expected to be less than 5.000 (Kock, 2020), and average path coefficient (APC) and average R^2 (ARS) which are both expected to be significantly different from zero for an adequate model. Hypothesized mediation effects were tested by calculating indirect effects using a "Stable 3" method recommended by Kock (2018) as it specifically aims to increase accuracy and statistical power. Hypothesized mediation effects were tested by calculating indirect effects using estimation of standard errors based on the "Stable 3" method (i.e. the method-specific standard errors) recommended by Kock (2018). This method is recommended because it aims to increase the accuracy and statistical power of the estimates. Specifically, Kock (2018) argues that the method-specific standard error of path coefficient estimates obtained via "Stable 3" are the closest to the actual standard errors of path coefficient estimates. Thus, the "Stable 3" method is not only stable, but also more accurate (Kock, 2018).

Results

Preliminary analyses

Attrition across the two data collection occasions resulted in a final sample size of 265 participants (male = 69, female, *n* = 196; M_{age} = 13.23 years, SD = .96, range 11 to 15; attrition rate = 27.1 %)[3]. Examination of skewness (range = -2.540 to 1.049) and kurtosis (range = -1.344 to 8.631) values suggested that all items, except one perceived autonomy support from the parent item

[3]Due to the pandemic virus (COVID-19) 129 participants out of 265 were forced to finish the study on-line which restricted them wearing the accelerometer-based device at the second data collection occasion. Therefore, for the test of the model with self-reported physical activity as the dependent variable (Model 1) the sample comprised 265 participants, whereas for the test of the model with physical activity measured by accelerometers as the dependent variable (Model 2) the sample comprised 136. An auxiliary analysis was performed on the model with self-reported physical activity as the dependent variable on participants (*n* = 136) whose results were not affected by the introduction of lockdown restrictions for COVID-19.

(skewness = -2.033), one attitude item (skewness = -2.540; kurtosis = 8.631) at wave one and one attitude item at wave two (skewness = -2.166) during first data collection occasion were within acceptable ranges (Byrne, 2010).

Focusing first on Model 1, at the first data collection occasion, participants spent on average 56.59 min (*SD* = 22.54) in moderate-to-vigorous PA a day at wave one and 63.60 min (*SD* = 21.86) at wave three. On the second data collection occasion they spent 38.08 min (*SD* = 25.87) in moderate-to-vigorous PA a day. Responses on the self-reported PA scale ranged between 4.26 and 4.46 points depending on the wave. Focusing on Model 2, at the first data collection occasion participants spent on average 57.26 min (*SD* = 21.24) in moderate-to-vigorous PA a day at wave one and 63.98 min (*SD* = 21.30) at wave three. On the second data collection occasion they spent 47.04 min (*SD* = 20.08) in moderate-to-vigorous PA a day. Responses on the self-report PA scale ranged between 4.47 and 4.59 points depending on the wave.

Intercorrelations among all study variables are presented in Table 1. For all measures, alpha values were above the cut-off criterion of 0.70 for measures taken in all waves and at both data collection occasions. The factor loadings of each indicator on its respective latent factor exceeded .700. GoF statistics indicated acceptable overall model fit with the data and model quality for Model 1 (GoF Index = .397; APC = .265, p = .001, ARS = .158, p = .002; AVIF = 1.135) and Model 2 (GoF Index = .394; APC = .266, p = .001, ARS = .155, p = .016; AVIF = 1.094).

[Table 1 near here]

Main analyses[4]

Direct effects

[4]Data files, analysis scripts, and outputs are available online at https://osf.io/mzbds/?view_only=dd0f1be08a8d4da6bb410401b03bec9d

Standardized path parameters for direct effects for Model 1 (N = 265) and Model 2 (N = 136) are presented in Figure 1[5]. Change in perceived autonomy support from PE teachers had a statistically significant direct effect on change in autonomous motivation in PE (H_1) in Model 1 (β = .35, p < .001) and Model 2 (β = .36, 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) in Model 1 (β = .34, p < .001) and Model 2 (β = .27, p < .001). Change in controlled motivation in PE had a significant direct effect on change in controlled motivation in a leisure-time context (H_3) in Model 1 (β = .39, p = .001) and Model 2 (β = .37, p < .001). Change in perceived autonomy support from parents and peers had significant direct effects on the change in autonomous motivation in a leisure-time context (H_4) in Model 1 (β = .19, p = .001 and β = .15, p = .007, respectively) and Model 2 (β = .21, p = .007 and β = .14, p = .046, respectively).

Change in autonomous motivation in a leisure-time context had a statistically significant direct effect on change in attitude (H_5) and PBC (H_6) in Model 1 (β = .16, p = .004; β = .38, p = .001, respectively) and Model 2 (β = .29, p < .001; β = .23, p = .002, respectively). Change in controlled motivation in leisure-time had a significant direct effect on the change in subjective norm (H_7) in Model 1 (β = .34, p = .001) and Model 2 (β = .51, p < .001). Change in attitude (H_8) and PBC (H_{10}) had significant direct effects on change in intention in Model 1 (β = .33, p = .001 and β = .45, p = .001, respectively) and Model 2 (β = .29, p < .001 and β = .43, p < .001, respectively). However, subjective norms had no statistically significant effects on intention (H_9) in either model.

Change in PBC had a significant direct effect on PA measured by self-report (H_{12}) in Model 1 (β = .12, p = .021), while change in PBC had a significant and negative direct effect on accelerometer-based PA in Model 2 (β = -.23, p = .003), so H_{12} was supported only in Model 1.

[5]An auxiliary analysis of the model with self-reported physical activity as the dependent variable was conducted on participants (n = 136) whose results were not affected by the introduction of lockdown restrictions for COVID-19.

Change in intention had a statistically significant but negative direct effect on change in PA measured by self-report (H_{11}) in Model 1 (β = -.16, p = .004), but not on PA measured by accelerometer-based devices in Model 2 (β = .10, p = .111), so H_{11} was rejected. Results of the auxiliary analysis in the sample of 136 participants with self-reported PA as the dependent variable, however, revealed a positive direct effect of change in PBC (β = .15, p = .035) and intention (β = .19, p = .012) on self-reported PA.

[Figure 1 near here]

Indirect effects

Indirect effects of the study constructs for both models are presented in Table 2. We found a statistically significant indirect effect of change in perceived autonomy support from the PE teacher on change in autonomous motivation in leisure-time through change in autonomous motivation in PE (H_{13}) in Model 1 (β = .12, p = .003), but not in Model 2 (β = .10, p = .054), although the effect fell short of statistical significance by a trivial margin. There was also an indirect effect of change in perceived autonomy support from parents on change in attitude through change in autonomous motivation in leisure-time (H_{14}) in Model 1 (β = .07, p = .046), but not in Model 2 (β = .06, p = .157). Finally, we found an indirect effect of change in PBC (H_{23}; β = -.07, p = .048), but not attitude (H_{22}; β = -.05, p = .113), on change in self-reported PA in Model 1 through change in intention, although the indirect effect for PBC on PA was negative in sign, contrary to predictions. The effect of change in autonomous motivation in leisure-time on change in intention was mediated by change in attitude and PBC (H_{18}) in Model 1 (β = .20, p = .001) and Model 2 (β = .18, p = .013).

The remaining proposed indirect effects were not statistically significant, including the indirect effects of changes in perceived autonomy support from different sources on social cognition constructs through change in autonomous motivation in leisure-time (H_{15}); the indirect effects of changes in autonomous motivation in leisure-time on self-reported PA through change in the social

cognition constructs and intention (H_{20}); and the indirect effects of change in autonomous motivation in PE on changes in intention through autonomous motivation in leisure-time and changes in social cognition constructs (H_{16}).

Finally, results of the auxiliary analysis for the model with self-reported PA as the dependent variable of participants whose results were not affected by COVID-19 revealed that the effect from change in PBC on change in self-reported PA (H_{23}) was not statistically significant ($\beta = .08$, $p = .089$). In model 2 there were no indirect effects of change in attitude ($\beta = .03$, $p = .314$) and PBC ($\beta = .04$, $p = .232$) on change in PA measured by accelerometer-based devices.

[Table 2 near here]

Discussion

The aim of the current study was to investigate the long-term predictive validity of the TCM over a one-year period to predict adolescents' out-of-school PA measured by self-reports (Model 1) and accelerometer-based devices (Model 2). The study investigated the longitudinal effects of perceived autonomy support from teachers, peers and parents on autonomous motivation towards PA in PE and leisure-time, social cognition beliefs about PA behaviour, and intentions toward, and actual participation in, out-of-school PA over a one-year time period. Results revealed that change in perceived autonomy support from PE teachers predicted change in adolescents' autonomous motivation in PE, and autonomous motivation in leisure-time over a one-year period in both models. Change in perceived autonomy support from peers and parents predicted change in autonomous motivation in leisure-time in both models. Change in autonomous motivation in leisure-time predicted change in intentions toward self-reported PA mediated by changes in attitude and PBC, for both models. Change in intention predicted change in self-reported PA negatively, but no significant relationship emerged between change in intention and accelerometer-based PA. The current study extends previous research by taking into account construct stability within the TCM, using a one-

year longitudinal design to evaluate whether model effects hold over an extended time period, and the use of accelerometer-based devices to measure students' PA.

Study findings are in line with several key hypotheses of the TCM (Hagger and Chatzisarantis, 2016): the relationship between perceived autonomy support and students' autonomous motivation in PE; the relationship between autonomous and controlled forms of motivation across contexts; and the indirect relationship between autonomous motivation in leisure-time and intentions through attitude and PBC. These relationships have received support in previous model tests in the PE (Hagger et al., 2005, 2009) and other education contexts, such as math and science lessons (Hagger et al., 2015; Hagger and Hamilton, 2018). Results provide preliminary evidence that key TCM relationships hold over a full year.

The current study also supports the relevance of additional sources of autonomy support in TCM over a full year. This is consistent with similar findings demonstrating effects of autonomy support from peers (Tilga et al., 2018) and parents (Wang, 2017) on adolescents' motivation toward PA over shorter time periods. The results are also in line with research using residual change scores to test the tenets of the TCM (Kalajas-Tilga et al., 2021). The current study extends previous findings by adding additional measurement points and using residual change scores over a one-year follow-up period. Results suggest that autonomy support from peers and parents are consistent predictors of adolescents' PA via constructs of the TCM over a longer period. These data suggest that including peer and parent autonomy support is important in future interventions to influence adolescents' motivation, beliefs, and out-of-school PA.

Contrary to the hypotheses, change in subjective norms did not predict change in intention. Also, change in subjective norms did not mediate the effect from change in controlled motivation in PE on change in intention. These data provide evidence to suggest that controlled motivation in PE might not be related to adolescents' PA intentions via subjective norms. Similar results have been

found in previous studies (Hagger et al., 2009; Hutmacher, et al., 2020). Subjective norms and controlled motivation seem to have marginal effects in the model compared to autonomous motivation, attitudes, and PBC.

The significant direct effect of change in PBC on self-reported PA in Model 1 is consistent with postulates of the TCM and with previous studies (e.g. Hutmacher et al., 2020; Kalajas-Tilga et al., 2021). However, this effect was negative in Model 2, a finding that runs contrary to the hypotheses. This is not, however, a unique finding; a similar finding was identified in previous research applying the model (Polet et al., 2020). A possible reason for this counterintuitive finding might be that students' assessment of their perceived control may be inaccurate. Students' control estimates may be consistent with their personal evaluations of their capability, which is likely to coincide with their self-reported PA, but it may be inaccurate when it comes to activity measured by non-self-report means.

A further counterintuitive result was the negative relationship between change in intention and change in self-reported PA. This finding is not in line with the hypotheses and is contrary to much of the previous research testing the TCM and research on the intention-behavior relationship in PA more broadly (Hagger et al., 2018; McEachan et al., 2011). One possible explanation for this unusual finding may be the timing of the study: the final study period fell in the spring of 2020 when very strict COVID-19 restrictions were introduced. Adolescents may have stated an intention to be physically active in the first wave of data collection but, due to the movement restrictions, were not able to follow through on them, so their predictions were inaccurate due to these unforeseen restrictions. To investigate this possibility, we performed an auxiliary analysis with participants whose completion of the study was unaffected by the introduction of the COVID-19 restrictions. The analysis demonstrated a significant and positive relationship between change in intention and change in self-reported PA, in line with previous studies (Hagger and Chatzisarantis, 2016; Polet et al.,

2020). These findings suggest that it is reasonable to assume that the introduction of restrictions might have affected the intention-behaviour relationship in those whose data were collected after COVID-19 outbreak. This is an illustration of how new information has the potential to affect relations in social cognition and motivational models of behaviour.

Consistent with previous research (Kalajas-Tilga et al., 2021), current findings did not demonstrate a relationship between change in intention and change in out-of-school PA. This is in contrast to previous research adopting the TCM (Hagger and Chatzisarantis, 2016), and previous research examining the long-term relationship between intention and PA behaviour (Raudsepp et al., 2010), using self-reported PA. Kalajas-Tilga et al. (2021) argued that this counterintuitive finding might be due to the lack of correspondence between the psychological constructs and the accelerometer-based device. In addition, the accelerometer-based device measured more types of activity while the psychological measures made specific reference to leisure-time PA, which means weak behavioural correspondence in the measures. The same reasons likely apply in the current study.

Strengths, limitations and future directions

The current study has several strengths including adoption of a longitudinal design over a one-year period, use of residual change scores to account for construct stability and change over time, and employment of accelerometer-based devices to measure PA. However, the study is not without its limitations. First, there were significantly more female than male participants, which may limit the generalizability of findings. However, it is important to note that we controlled for gender in our analyses, which means that observed effects are unlikely to have been adversely affected by gender variations. Future research should be proactive in the recruitment of male adolescents. Second, the small sample size of the current study is another limitation. Future studies should replicate the current model in larger samples by recruiting a larger sample in the first wave of data collection

given the likely drop-out rate. Another approach would be to be more proactive in retaining participants across the waves of the study. Third, although accelerometer-based devices are considered more accurate while evaluating PA, they have limitations. For example, they are not able to capture certain activities such as water-based activities, cycling on a stationary bicycle, and doing weight-lifting, which could result in an underestimation of activity levels. The use of a diary in conjunction with accelerometers is recommended to provide converging estimates of PA (Van Hoye et al., 2013). Fourth, complementary to the self-reported measures of autonomy support from teacher, parents and peers, we recommend that future research provides an externally-referenced assessment of autonomy support from the three socializing agents using observational instruments rather than relying on perceived autonomy support. Fifth, data from the current study are correlational, so we cannot infer causality from the proposed effects. Future studies are suggested to gather intervention or experimental data to draw more causal conclusions on effects, such as interventions aimed at manipulating key constructs in the model.

Conclusions

Results of the current study support some of the main hypotheses of the TCM over a one-year time period. The results of the study demonstrate the importance of change in perceived autonomy support from PE teachers, peers and parents in the prediction of change in autonomous motivation toward physical activities in PE and in leisure-time. Findings also provide support for the link between change in leisure-time autonomous motivation and change in theory of planned behaviour constructs over a full year. However, the present study did not demonstrate the association between change in intention and change in behaviour. The study extends previous research adopting the TCM by demonstrating the longitudinal predictive validity and the stability of the model constructs, but also raises some concerns given the lack of association between intention and behavior. Future studies are needed to verify the current findings over a long-term period.

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Table 1

Zero-order Intercorrelations for Study Variables

Variable	Correlation											
	1	2	3	4	5	6	7	8	9	10	11	12
1. PAS (PE teacher)	1	.17*	.26**	.35***	.20*	.03	.10	.16	.18*	.15	.16	-.05
2. PAS (Parent)	.27***	1	.40***	.16	.28***	-.10	.01	.19*	-.02	.32***	.12	-.16
3. PAS (Peer)	.24***	.43***	1	.03	.22*	.04	.09	.17*	.13	.23**	.03	.04
4. AM PE	.27***	.28***	.14*	1	.27**	.12	.28***	.12	.06	.07	.20*	.09
5. AM LT	.16*	.29***	.17**	.29***	1	.08	.22**	.29***	.15	.17*	.34***	.07
6. CM PE	.07	-.08	.03	.16**	.09	1	.34***	.04	.03	-.07	-.09	.15
7. CM LT	.17**	.03	.01	.15*	.27***	.37***	1	.18*	.44***	.05	.00	.03
8. Attitude	.07	.18**	.15*	.14*	.37***	.04	.19**	1	.14	.28***	.36***	-.07
9. Subjective norm	.12	.08	.12	.03	.11	.03	.33***	.19**	1	.17	.09	.04
10. PBC	.11	.25***	.20***	.08	.15*	-.05	.03	.29***	.21***	1	.48***	-.13
11. Intention	.09	.14*	.09	.19**	.33***	-.03	.05	.44***	.18**	.53***	1	.02
12. LT MVPA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1
13. Self-reported PA	-.13*	-.09	-.03	-.01	-.06	-.01	.01	.03	-.05	.02	-.04	N/A

Note. Correlations for a sample N = 265 are shown below the diagonal and correlation for a sample N = 136 are shown above the diagonal. Out-of-school moderate-to-vigorous physical activity (MVPA) was calculated in min/day.
All the study variables are residual change scores. PAS = Perceived autonomy support; AM = Autonomous motivation; CM = Controlled motivation; PE = Physical education; PBC = Perceived behavioural control; LT = Leisure time. *p < .05. **p < .01. ***p < .001.

Table 2

Standardized (β) Parameter Estimates for the Indirect Effects from the Partial Least Squares Analysis of the Trans-Contextual Model Using Residual Change Scores

H	Independent variable	Dependent variable	Mediator(s)	β_1	β_2	β_3
Indirect effects						
H_{13}	PAS (PE teacher)	AM (LT)	AM (PE)	.12**	.10	.10
H_{14}	PAS (parent)	Attitude	AM (LT)	.07*	.06	.06
	PAS (peer)			.06	.04	.04
H_{15}	PAS (parent)	PBC	AM (LT)	.03	.05	.05
	PAS (peer)			.02	.03	.03
H_{16}	AM (PE)	Intention	AM (LT)	.07	.05	.05
H_{17}	CM (PE)	Intention	Attitude/PBC CM (LT)	.01	.00	.00
H_{18}	AM (LT)	Intention	Subjective norm Attitude/PBC	.20***	.18*	.18*
H_{19}	CM (LT)	Intention	Subjective norm	.03	-.01	-.01
H_{20}	AM (LT)	LT MVPA	Attitude/PBC	–	-.02	–
		Self-reported PA	Intention	-.03	–	.03
H_{21}	CM (LT)	LT MVPA	Subjective norm	–	.00	–
		Self-reported PA	Intention	-.01	–	.00
H_{22}	Attitude	LT MVPA	Intention	–	.03	–
		Self-reported PA		-.05	–	.05
H_{23}	PBC	LT MVPA	Intention	–	.04	–
		Self-reported PA		-.07*	–	.08
Total effects						
H_{24}	PAS (PE teacher)	Intention		.02	.02	.02
H_{25}	PAS (PE teacher)	LT MVPA		–	.00	–
		Self-reported PA		.00	–	.01

Note. H = Hypotheses. β_1 = Standardized parameter estimates for the model in which physical activity was measured by self-reports (N = 265). β_2 = Standardized parameter estimates for the model in which physical activity was measured by accelerometers (N = 136). β_3 = Standardized parameter estimates for the model in which physical activity was measured by self-report (N = 136). All the study variables are residual change scores. PAS = Perceived autonomy support; AM = Autonomous motivation; CM = Controlled motivation; PE = Physical education; PBC = Perceived behavioural control; LT = Leisure time; MVPA = Moderate-to-vigorous physical activity (accelerometer-based). *p < .05. **p < .01. ***p < .001.

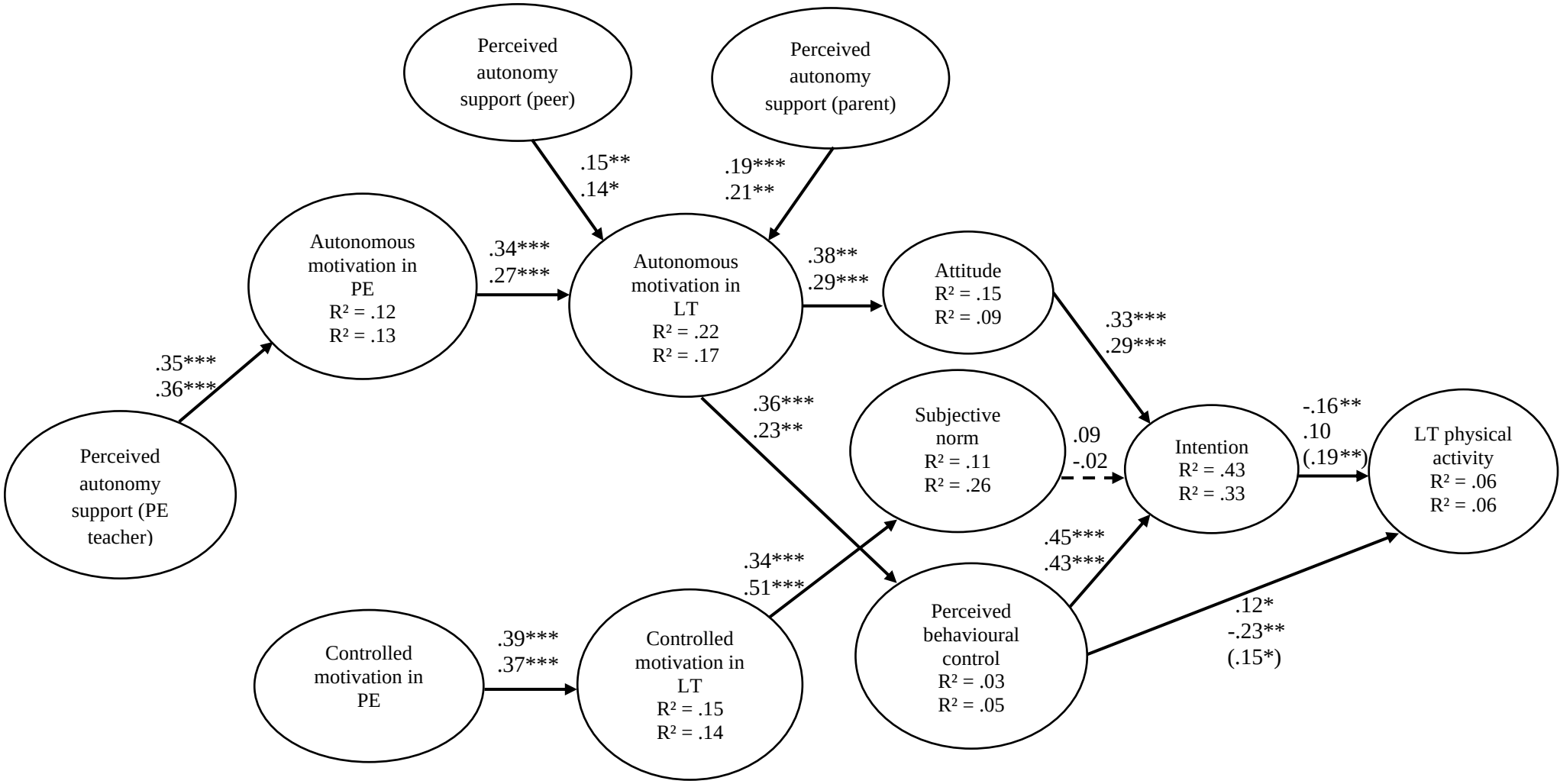
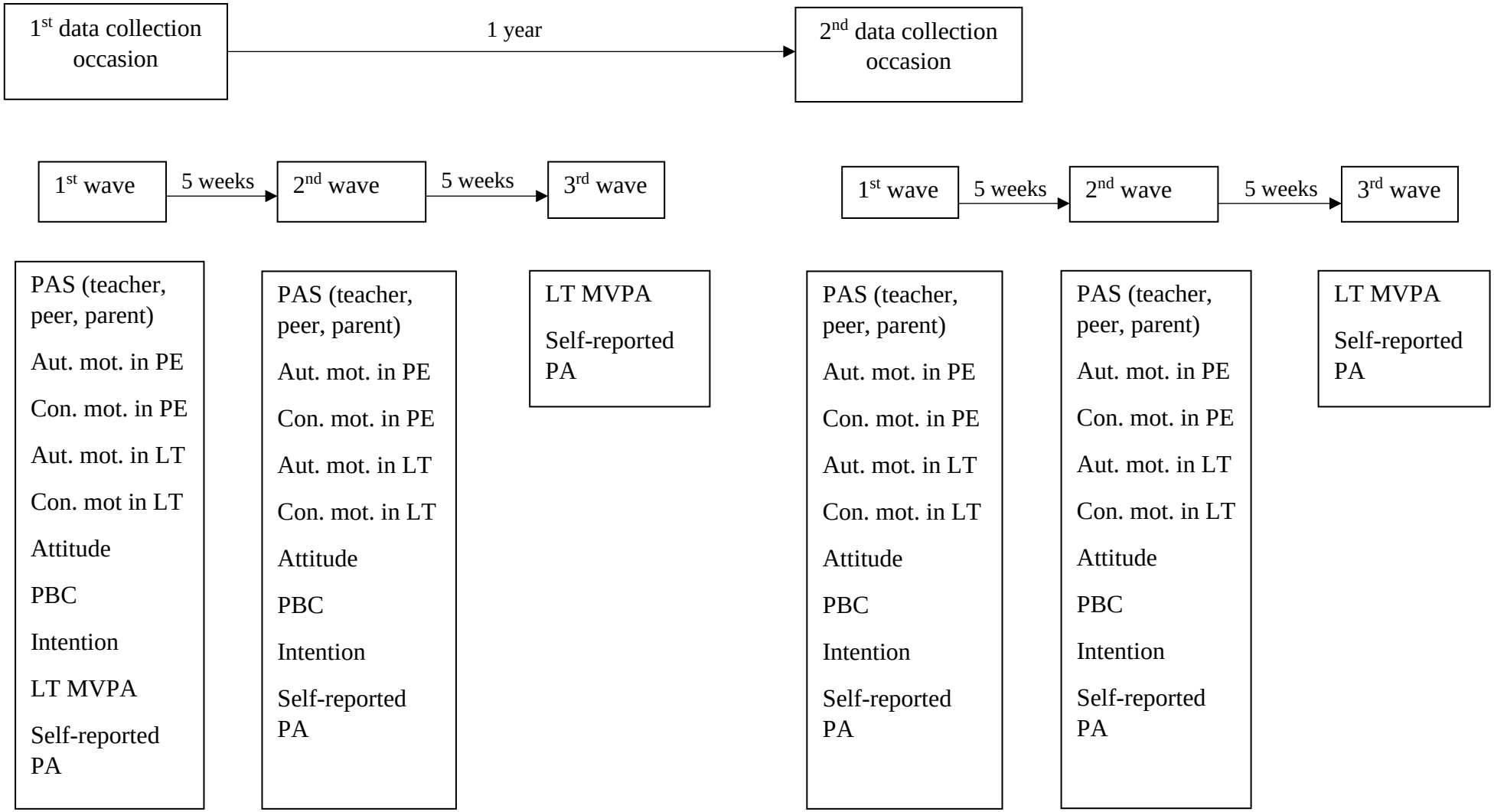


Figure 1. Standardized path coefficients for the longitudinal structural equation model testing change in trans-contextual model predictions for leisure-time self-reported and out-of-school moderate-to-vigorous physical activity measured by accelerometers. All variables represented in the diagram are residualised change scores. Values printed on the upper line are for the model with physical activity measured by self-report (N = 265) and values printed on the lower line are for the model with physical activity measured by accelerometer-based devices (N = 136). Values in parentheses represent the results of the auxiliary analysis where physical activity was measured by self-report (N = 136). Paths between past behaviour and the study constructs are not shown for clarity. PE = Physical education context; LT = Leisure-time context. *p < .05. **p < .01. ***p < .001.



Appendix A. The longitudinal study design.
PAS = Perceived autonomy support; Aut.mot. = Autonomous motivation; Con.mot. = Controlled motivation; PE = Physical education context; LT = Leisure-time context; PBC = Perceived behavioural control; PA = Physical activity; MVPA = Moderate-to-vigorous physical activity measured by accelerometers.