

How is observed (de)motivating teaching associated with student motivation and device-based physical activity during physical education?

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Abstract

Previous Self-Determination Theory (SDT) research has highlighted the impact of physical education (PE) teachers' (de)motivating styles on students' motivation, in-class moderate-to-vigorous physical activity (MVPA), and sedentary behaviour. However, most studies relied on questionnaires to assess PE teachers' (de)motivating styles, and the few that used observations focused primarily on one specific (de)motivating style in relation to motivational outcomes, overlooking behavioural

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outcomes. This study advances SDT-based research by examining associations between PE teachers' observed (de)motivating styles (i.e. four styles, eight approaches, and 43 behaviours), students' motivation (i.e. intrinsic motivation, identified regulation, introjected regulation, external regulation, and amotivation), and students' device-based in-class MVPA and sedentary behaviour. A total of 79 secondary school PE teachers and 885 students participated. One PE lesson per teacher was recorded and (de)motivating styles were rated using the Situation-in-School Physical Education-Coder (SIS-PE-Coder). Students completed an online questionnaire to assess their motivation and wore Actigraph accelerometers to measure in-class MVPA and sedentary behaviour. Linear mixed-effects models, controlling for the lesson topic, and students' sex and age, revealed that PE teachers' observed attuning approach related positively and demanding and abandoning approaches related negatively to students' intrinsic motivation. The demanding approach also related positively to students' introjected regulation. Notably, the demanding approach showed a dual pathway, negatively relating to intrinsic motivation but positively relating to in-class MVPA. In turn, intrinsic motivation was positively related to in-class MVPA. By relying on observations, the findings suggest that PE teachers can optimize student motivation by being more attuning and less demanding and abandoning.

Keywords

Self-Determination Theory, circumplex model, accelerometer, sedentary behaviour, MVPA

Introduction

Physical education (PE) curricula worldwide have many goals, aiming to develop motor and social competencies and promoting a healthy lifestyle (Kirk, 2009; Opstoel et al., 2020). However, debates persist on which goals to prioritize (Haerens et al., 2016). Public health researchers emphasize increasing in-class moderate-to-vigorous physical activity (MVPA) as it provides immediate health benefits, and limiting in-class sedentary behaviour as it is associated with negative health outcomes (Sallis et al., 2012). Pedagogical researchers caution against making this the sole focus, as PE teachers might pressure students to be highly active, potentially undermining students' motivation (Haerens et al., 2016). Instead, they advocate for fostering enjoyment during the PE lesson, enhancing students' motivation for PE to the benefit of their physical activity behaviour outside school (Hagger and Chatzisarantis, 2016; Ntoumanis et al., 2021). All agree however that an optimal learning climate is created if teachers rely on motivating rather than demotivating interactions, reduce sedentary time, and enhance MVPA to realize the wide range of goals of PE (Haerens et al., 2016).

Self-Determination Theory (SDT; Ryan and Deci, 2017) offers insight into how student–teacher interactions affect motivation, in-class physical activity, and sedentary behaviour. According to SDT, motivating PE teachers foster students' motivation (Tilga et al., 2023; Vasconcellos et al., 2020), enhance in-class MVPA (Ha et al., 2020; Lonsdale et al., 2019), and reduce sedentary behaviour (Ha et al., 2020; Lonsdale et al., 2013), while demotivating PE teachers undermine students' motivation (Burgueño et al., 2024; Vasconcellos et al., 2020) and reduce in-class MVPA (Van Doren et al., 2021).

Most SDT-based studies relied on students' self-reports, capturing each student's perception of the teacher. Although student-reports have stronger predictive power than teachers' perceptions or external observations (De Meyer et al., 2014), incorporating observational measures can offer a

contextualized and ecologically valid perspective on how teachers actually behave in the classroom (Haerens et al., 2013). These insights complement self-reports, providing concrete recommendations for teacher education on how to optimally behave in the classroom.

Although some previous studies have employed observations to assess PE teachers' (de)motivating interactions, they often focus on one specific style (e.g. De Meyer et al., 2014; Reeve et al., 2004). The recently developed Situation-in-School Physical Education-Coder (SIS-PE-Coder) (Van Doren et al., 2023) is a comprehensive observational instrument based on the circumplex model (Escriva-Boulley et al., 2021), offering a promising way to investigate PE teachers' observed (de)motivating teaching (i.e. four styles, eight approaches, and distinct behaviours).

The present study aims to advance SDT-based research by using the SIS-PE-Coder (Van Doren et al., 2023) to examine associations between observed (de)motivating teaching (i.e. four styles, eight approaches, and specific behaviours), student motivation, in-class MVPA, and sedentary behaviour. In doing so, our study extends previous SDT research by not only focusing on the important role of PE teachers in shaping students' motivation for PE, but also in determining students' in-class MVPA and sedentary behaviour, contributing to the ongoing debate of which goal to prioritize.

A circumplex model of four (de)motivating styles and eight approaches

The SDT-based circumplex model (Escriva-Boulley et al., 2021) depicts PE teachers' (de)motivating teaching along two axes: a motivating and a directiveness axis. This results in four styles: autonomy support (i.e. motivating, low directiveness), structure (i.e. motivating, high directiveness), control (i.e. demotivating, high directiveness), and chaos (demotivating, low directiveness). Each style gets further refined into two approaches (see Figure 1; Escrive-Boulley et al., 2021).

Autonomy support, a motivating style, involves seeking to identify and nurture students' interests to voluntarily engage in PE. Autonomy support is divided into a participative and attuning approach. A participative approach includes offering choice, asking for students' input, and welcoming their suggestions. An attuning approach includes acknowledging students' negative feelings, offering a meaningful rationale, and making the activities more enjoyable. Structure, another motivating style, involves starting from the capabilities of the students by providing help, so students feel competent. Structure can be divided into a guiding and a clarifying approach. A guiding approach includes expressing confidence in students' capabilities, encouraging students, and giving positive and constructive feedback. A clarifying approach includes setting clear and transparent goals, and consistently following up with students (Escriva-Boulley et al., 2021).

Control, a demotivating style, involves actively undermining students' volitional functioning, through demanding and/or domineering approaches. A demanding approach includes using commanding language, using sanctions, and relying on rewards. A domineering approach includes the use of power, intimidation, guilt-induction, and shaming. Lastly, chaos, another demotivating style, involves acting inconsistently, which creates confusion and interferes with students' achievement of the desired outcomes. Chaos can be subdivided into an abandoning and awaiting approach. An abandoning approach includes leaving students to their own devices and giving up on students. An awaiting approach includes not planning too much and waiting to see how the lesson unfolds (Escriva-Boulley et al., 2021).

Associations between PE teachers' (de)motivating teaching and student motivation

According to SDT (Ryan and Deci, 2017), student motivation can be categorized into five different forms: intrinsic motivation (i.e. inherent pleasure), identified regulation (i.e. personal relevance),

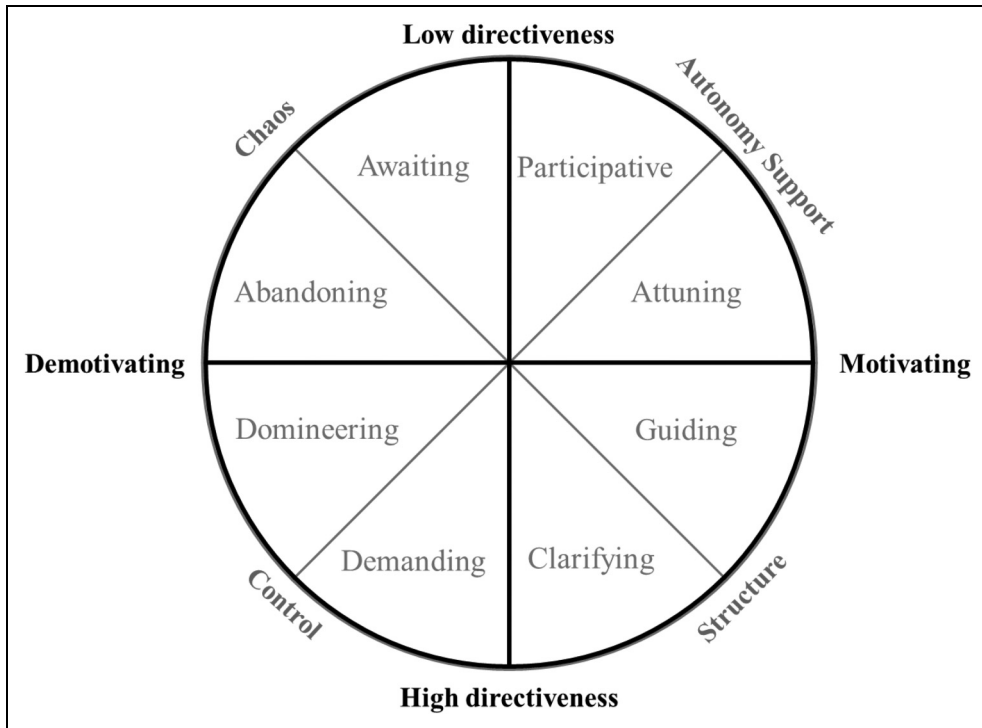


Figure 1. Circumplex model of PE teachers' (de)motivating styles and approaches (adopted from Escrivá-Boulley et al., 2021).

introjected regulation (i.e. internal pressure), external regulation (i.e. external pressure), and amotivation (i.e. complete absence of motivation). As certain forms of motivation are more volitional and others are pressured, they are also referred to as respectively autonomous (i.e. intrinsic motivation and identified regulation) and controlled (i.e. introjected and external regulation) motivation (Ryan and Deci, 2017).

SDT posits that PE teachers' autonomy-supportive and structuring styles positively relate to intrinsic motivation and identified regulation, and negatively to introjected regulation, external regulation, and amotivation, while the opposite is true for controlling and chaotic styles (Ryan and Deci, 2017). Recent cross-sectional (Jankauskiene et al., 2022; Leo et al., 2023; Tilga et al., 2023), person-centered (Burgueño et al., 2024; García-González et al., 2023), and longitudinal (Behzadnia et al., 2023) research using self-reported measures largely corroborated these theorized associations. A meta-analysis summarizing research up until the year 2017 (Vasconcellos et al., 2020) showed that PE teachers' autonomy-supportive and structuring styles positively relate to students' intrinsic motivation, identified and introjected regulation, and negatively to external regulation and amotivation, while PE teachers' controlling style positively relates to students' introjected regulation, external regulation, and amotivation. However, PE teachers' chaotic style remains largely under-researched.

While student-reported studies have primarily confirmed SDT's theoretical associations, research relying on observations of PE teachers' (de)motivating styles has generally revealed

weaker and less consistent results. Some studies found significant associations between PE teachers' autonomy-supportive (Cheon et al., 2012; Van Doren et al., 2023), structuring (Teraoka et al., 2023; Van Doren et al., 2023), controlling (De Meyer et al., 2014; Van Doren et al., 2023), and chaotic style (Van Doren et al., 2023) and students' motivation. However, other studies did not find such associations, with researchers suggesting this might be due to small sample sizes (Sarrazin et al., 2006; Teraoka et al., 2023).

The circumplex model (Escriva-Boulley et al., 2021) allows for a more refined examination of these associations. According to this model, the attuning and guiding approaches are considered the most motivating (as both approaches have the strongest correlation with autonomous motivation), while the domineering and abandoning approaches are viewed as the most demotivating (as both approaches have the strongest correlation with controlled motivation and amotivation) (Escriva-Boulley et al., 2021). Consequently, the strongest positive correlations with intrinsic motivation and identified regulation are expected for the attuning and guiding approaches, and these correlations are expected to become negative as one moves along the circumplex towards domineering and abandoning. A similar but reverse pattern is expected for introjected regulation, external regulation, and amotivation. While no questionnaire-based research has examined PE teachers' (de)motivating approaches in relation to student motivation, previous questionnaire-based research in other contexts supports these theoretical associations (Aelterman et al., 2019; Delrue et al., 2019).

Associations between PE teachers' (de)motivating teaching and students' in-class MVPA and sedentary behaviour

SDT theorizes that PE teachers' (de)motivating style not only influences students' motivational outcomes but also their behavioural outcomes (Ryan and Deci, 2017). From a motivational perspective, SDT (Ryan and Deci, 2017) theorizes that autonomy-supportive and structuring PE teachers can encourage students to engage in more MVPA and reduce sedentary behaviour during PE by fostering their intrinsic motivation and identified regulation. Conversely, SDT suggests that controlling and chaotic PE teachers may discourage in-class MVPA and increase sedentary behaviour by nurturing introjected regulation, external regulation, and amotivation for PE. However, associations between PE teachers' (de)motivating style and in-class MVPA might not be as straightforward. For example, some motivating behaviours (e.g. asking students about their interests) might influence student motivation for the better but might decrease in-class MVPA. Similarly, certain demotivating behaviours (e.g. using punishments) might reduce student motivation but can increase their in-class MVPA (Haerens et al., 2016).

Intervention studies have focused on the direct association between PE teachers' student-reported motivating styles and students' accelerometer-measured in-class MVPA and sedentary behaviour, showing that positive changes in PE teachers' motivating styles can increase students' MVPA (Ha et al., 2020; Lonsdale et al., 2019; Lonsdale et al., 2013) and reduce sedentary behaviour during PE (Ha et al., 2020; Lonsdale et al., 2013). However, these interventions targeted various aspects of PE teachers' motivating styles simultaneously (e.g. providing feedback and giving students choices, respectively structuring and autonomy-supportive behaviours), making it difficult to isolate specific effects. Furthermore, only one study examined PE teachers' student-reported controlling style in relation to students' accelerometer-measured in-class MVPA, revealing a negative association (Van Doren et al., 2021). No research has investigated

PE teachers' chaotic style nor the other (de)motivating approaches in relation to students' in-class MVPA and sedentary behaviour. Research using observations to assess PE teachers' (de)motivating style in relation to students' in-class MVPA and sedentary behaviour is scarce. One study revealed that if PE teachers relied more on autonomy-supportive and structuring behaviours, their students were more likely to achieve the recommended in-class MVPA levels (50% of the lesson time; People, 2000; Petrušić and Štemberger, 2021).

Only one study investigated the indirect pathways through students' motivation (Van Doren et al., 2021). While initial correlations indicated a potential pathway from student-reported motivating styles to their accelerometer-measured in-class MVPA through autonomous motivation, these associations did not hold in the full model when accounting for students' sex and the lesson topic. No research has yet investigated PE teachers' observed (de)motivating styles or approaches in relation to students' in-class MVPA and sedentary behaviour through students' motivation.

Gaps and pressing issues

Several gaps can be noted in the literature. First, most studies relied on student-reports to assess PE teachers' (de)motivating styles. Although student-reports provide valuable insights into students' perceptions of PE teachers' behaviours, associations with student-reported outcomes (i.e. motivation, MVPA, and sedentary behaviour) may be inflated due to common method bias (Podsakoff et al., 2003). Additionally, student perceptions of the same teacher vary significantly (Burgueño et al., 2024), complicating recommendations for teachers. Observations can complement student-reported research by assessing teachers' actual behaviour (Haerens et al., 2013).

Research exploring the association between PE teachers' observed (de)motivating styles and student motivation revealed inconsistent findings. This discrepancy may arise from using different observational instruments, some of which rely on small sample sizes (e.g. Teraoka et al., 2023) and assess only three behaviours to determine a specific style (e.g. De Meyer et al., 2014). Additional research using observations is necessary, emphasizing the importance of assessing all (de)motivating styles, approaches, and specific behaviours.

Lastly, studies on PE teachers' (de)motivating styles and students' in-class MVPA and sedentary behaviour focused on the motivating side (Ha et al., 2020; Lonsdale et al., 2019), entangling various motivating styles and overlooking demotivating styles. Further research is needed to identify which specific behaviours are most effective and to understand the effects of demotivating styles, approaches, and behaviours. This is particularly important to investigate in light of the ongoing debate regarding which goal of PE to prioritize (i.e. Haerens et al., 2016; Sallis et al., 2012).

Present research

To address the previously mentioned gaps, this study investigates associations between PE teachers' observed (de)motivating teaching (i.e. all four styles and eight approaches of the circumplex model, and specific behaviours), student motivation (i.e. all five forms), and accelerometer-measured MVPA and sedentary behaviour. Given the inconsistency in the available findings, we considered the existing research but primarily ground our hypotheses in theory. We hypothesize, based on SDT (Ryan and Deci, 2017) and the circumplex model (Escriva-Boulley et al., 2021), that:

Hypothesis 1: PE teachers' (de)motivating teaching will be associated with students' motivation. Specifically:

H1a: We hypothesize that PE teachers' observed autonomy-supportive (i.e. participative and attuning) and structuring style (i.e. guiding and clarifying) will positively relate to students' intrinsic motivation and identified regulation, and negatively to introjected regulation, external regulation, and amotivation, with PE teachers' attuning and guiding approaches showing the strongest associations.

H1b: We hypothesize that PE teachers' controlling (i.e. demanding and domineering) and chaotic style (i.e. abandoning and awaiting) will negatively relate to students' intrinsic motivation and identified regulation, and positively to introjected regulation, external regulation, and amotivation, with PE teachers' domineering and abandoning approaches showing the strongest associations.

Hypothesis 2: PE teachers' (de)motivating teaching will relate to students' in-class MVPA and sedentary behaviour. Specifically:

H2a: PE teachers' autonomy-supportive (i.e. participative and attuning) and structuring style (i.e. guiding and clarifying) could positively relate to students' in-class MVPA and negatively to their sedentary behaviour (by fostering students' motivation), with PE teachers' attuning and guiding approaches showing the strongest associations. However, certain autonomy-supportive (e.g. asking students about their interests) and structuring behaviours (e.g. giving an overview of the PE lesson) could temporarily reduce students' in-class MVPA.

H2b: Similarly, PE teachers' controlling (i.e. demanding and domineering) and chaotic style (i.e. abandoning and awaiting) could negatively relate to students' in-class MVPA and positively to their sedentary behaviour (by undermining students' motivation), with PE teachers' domineering and abandoning approaches showing the strongest associations. However, certain controlling (e.g. using punishments) and chaotic behaviours (e.g. allowing chaos and disorder) could potentially lead to increased students' in-class MVPA. As such, two possible contradictory hypotheses will be examined.

Hypothesis 3: When significant associations are found between PE teachers' (de)motivating teaching and student motivation, and between PE teachers' (de)motivating teaching and student in-class MVPA and sedentary behaviour, we expect the latter associations to be indirectly explained via students' motivation.

Method

Study design and recruitment

For this cross-sectional study, a convenience sample of 204 Flemish secondary schools was contacted via email, telephone, or in-person visits. Schools were identified through a public database from the Flemish Ministry of Education, listing schools near the researchers' institution. Once schools expressed interest, their PE teachers received details regarding the study's protocol. Participating PE teachers selected one class in consultation with the researcher, considering

scheduling constraints. All students in the selected class were invited to participate. Informed consent forms were signed by school board members, PE teachers, students, and their parents or legal guardians. This study was approved by the Medical Ethics Committee of UZ Ghent (BC-08933).

Sample

In total, 79 PE teachers from 48 schools (schools' response rate: 23.53%) participated in this study. Teachers were on average 38.06 (SD = 9.03; range = 22.47–63.34) years old, had on average 14.23 (SD = 8.59; range = 0–40) years of experience, and more than half of them were men (45 men and 34 women). A total of 885 students were involved in this study, of which 775 (87.57%) wore an accelerometer during the PE lesson. Students were on average 15.37 years old (SD = 1.60; range = 11.91–20.08; calculated using students' birthdates and the date of data collection) and almost 60% of them were girls (368 boys, 513 girls, and 4 preferred not to say). The average number of participating students per teacher was 11.20 (SD = 5.10; range = 1–22).

Procedure

Data collection involved three steps: (1) video and audio recording of one PE lesson to later observe (de)motivating teaching, (2) distributing and mounting accelerometers to assess students' in-class MVPA and sedentary behaviour, and (3) administering an online questionnaire to students to describe their motivation for the past lesson. Due to the limited availability of accelerometers ($N = 18–20$), they were randomly distributed among the students.

Measures

To assess PE teachers' observed (de)motivating teaching, the valid and reliable SIS-PE-Coder was used (Van Doren et al., 2023). In total, 19 motivating behaviours and 24 demotivating behaviours were assessed, reflecting the four (de)motivating styles and eight approaches: autonomy support (9 items; $\alpha = .73$) including participative (4 items; $\alpha = .57$) and attuning (5 items; $\alpha = .73$), structure (10 items; $\alpha = .83$) including guiding (6 items; $\alpha = .75$) and clarifying (4 items; $\alpha = .71$), control (13 items; $\alpha = .80$) including demanding (6 items; $\alpha = .55$) and domineering (7 items; $\alpha = .76$), and chaos (11 items; $\alpha = .83$) including abandoning (5 items; $\alpha = .84$) and awaiting (6 items; $\alpha = .85$). Each behaviour is preceded by the stem 'If you were a student in this class, would you feel that the teacher....' Each behaviour was rated on a 7-point potency scale (i.e. considering the frequency and the intensity/quality of the observed behaviours), ranging from 0 (PE teacher does not exhibit this behaviour), through 3 (PE teacher exhibits the behaviour in a moderately motivating/demotivating way), to 6 (PE teacher exhibits the behaviour in a highly motivating/demotivating manner). All 43 behaviours were rated every 5 minutes. Interval ratings were summed and divided by the number of intervals, creating mean scores for every behaviour. Dimensional scores were then computed by averaging those mean scores of behaviours reflecting each of the four styles and eight approaches. All videotapes were rated by one expert (i.e. first author), a researcher in the SDT field who has experience with teaching secondary school PE and was part of the original validation study of the SIS-PE-Coder. Three minor adaptations were made to the instrument to address limitations identified in previous research (see Supplementary Material S1, e.g. absence of a prevalent demanding behaviour) (Van Doren et al., 2023). Following Bakeman

and Goodman's (2020) guidelines, intrarater reliability (11 lessons coded twice, with a two-week interval) and interrater reliability (another expert, fifth author, also coding 20 lessons) were assessed using Intraclass Correlation Coefficients (ICC) (see Supplementary Material S1), with ICC values above .75 indicating good reliability (Portney and Watkins, 2009).

To assess students' situational motivation, the valid and reliable Dutch version of the Behavioral Regulations in Physical Education Questionnaire (BRPEQ) was used (Aelterman et al., 2012; Markland and Tobin, 2004). The BRPEQ assesses five types of motivation, preceded by the stem 'I put effort into the past PE lesson because....' More specifically, the BRPEQ assesses students' intrinsic motivation ($\alpha = .88$), identified regulation ($\alpha = .76$), introjected regulation ($\alpha = .63$), external regulation ($\alpha = .67$), and amotivation ($\alpha = .81$), each represented by four items. Each item is rated on a five-point Likert scale ranging from 1 (completely disagree) to 5 (completely agree).

To assess students' in-class MVPA and sedentary behaviour, students wore a valid and reliable triaxial Actigraph GT3x (+) accelerometer on their right hip during the lesson (Troost et al., 2006). This accelerometer captures movements on three orthogonal axes within predefined intervals (i.e. epochs), set at 15-second intervals. The recorded movements were processed to generate activity counts. Activity counts were analysed to determine the time spent at various activity intensities by applying specific cut-off points (i.e. sedentary behaviour: 0–100 counts per minute, and MVPA: ≥ 296 counts per minute) (Evenson et al., 2008). As the duration of the PE lesson varied (with lesson time recorded by the present researcher, excluding the time students spent transitioning to the gym and changing), the time spent in MVPA and sedentary behaviour was converted into percentages of lesson time spent in MVPA and sedentary behaviour (i.e. time spent divided by lesson time). This process, from raw movement data to percentages of lesson time spent in various activity intensities, was performed in Python using the following two libraries: `pygt3x`¹ and `agcounts`.²

Plan of analyses

Preliminary analyses were conducted in R 4.3.0, including class-level descriptive statistics and Pearson correlations. To examine H1 and H2, two-level linear mixed-effects models were used with students (level 1) nested within classes or teachers (level 2; one class per teacher). The models were fitted using the `lme()` function from the `nlme` package in R 4.3.0. A random intercept was specified for each class (or teacher). Two-level analyses were chosen over three-level analyses since the school and class (or teacher) levels were largely confounded (there was only one class or teacher per school; 32 out of 48 schools; 66.67%). Likelihood ratio tests indicated that the three-level model did not significantly outperform the two-level model, and the variance explained by the school level did not reach significance.

For each of the seven outcome variables (i.e. students' five forms of motivation, in-class MVPA, and sedentary behaviour), a null model was estimated to assess the variance attributable to both student and teacher levels. Subsequently, PE teachers' four (de)motivating styles, eight approaches, and behaviours (i.e. 43 individual behaviours from the SIS-PE-Coder, Van Doren et al., 2023) were separately incorporated into the null model. In line with previous research (Aelterman et al., 2012; Van Doren et al., 2021; Viciano et al., 2017), the lesson topic, and students' sex and age were added as control variables. Lesson topics were categorized into four groups (Aelterman et al., 2012; Van Doren et al., 2021): ball games (e.g. soccer, basketball; 26 classes; 32.9%), artistic sports (e.g. dance, gymnastics; 28 classes; 35.4%), fitness and track (e.g. running, step aerobics; 14 classes; 17.7%), and racket games (e.g. badminton, table tennis; 11 classes; 13.9%).

The Benjamini-Hochberg (BH) procedure was used to account for multiple comparisons (i.e. multiplicity), managing the likelihood of mistakenly identifying false positives (i.e. false discovery rate) (Benjamini and Hochberg, 1995). The procedure was applied for each set of predictors (i.e. styles, approaches, and behaviours) and each outcome variable.

When the following three conditions were met: (1) significant association between PE teachers' (de)motivating styles, approaches, or behaviours and students' in-class MVPA and/or sedentary behaviour, (2) significant association between PE teachers' (de)motivating styles, approaches, or behaviours and students' motivation, and (3) significant association between students' motivation and students' in-class MVPA and/or sedentary behaviour, two-level path models were run in MPlus Version 8 (Muthén and Muthén, 2010) to examine indirect effects (H3). The lesson topic and students' sex and age were included as covariates. Model fit was assessed using the comparative fit index (CFI), Tucker–Lewis index (TLI), root-mean-square error of approximation (RMSEA), and standardized root-mean-square residual (SRMR). Acceptable model fit was determined based on the following criteria: $CFI > 0.95$, $TLI > 0.95$, $RMSEA < 0.08$, and $SRMR < 0.08$ (Hu and Bentler, 1999).

Results

Preliminary analyses

On average, students spent 54.70% (SD = 14.70) of the PE lesson in MVPA and 6.00% (SD = 9.01) in sedentary behaviour (see Table 1). About two-thirds (66.20%) of the students achieved the recommended amount of MVPA during PE (i.e. 50%; People, 2000). Table 1 further presents class-level descriptive statistics and Pearson correlations for the study variables (see also Supplementary Material S2).

Main analyses

Relation between PE teachers' observed (de)motivating teaching and student motivation (H1). In total, between 3% and 9% of the variance in students' motivation was situated at the class level (see Table 2), with class-level variance not reaching significance for students' external regulation. As hypothesized (H1a), PE teachers' observed attuning approach related positively to intrinsic motivation ($\beta = .12, p = .02$) (see Table 3). Specifically, when PE teachers were observed to offer more activities students found fun ($\beta = .15, p = .01$) and innovative ($\beta = .11, p = .04$), students reported higher levels of intrinsic motivation (see Supplementary Table S3). Contradictory to H1a, no other associations were found between PE teachers' observed motivating styles (i.e. autonomy support and structure) or approaches (i.e. participative, guiding, and clarifying approaches) and motivation (see Table 3).

In line with Hypothesis 1b, PE teachers' observed demanding approach related negatively to intrinsic motivation ($\beta = -.11, p = .03$) and positively to introjected regulation ($\beta = .14, p = .05$). Specifically, when PE teachers were observed to put pressure on students to meet certain deadlines ($\beta = -.13, p = .01$), students experienced less intrinsic motivation, but none of the demanding behaviours related to introjected regulation (see Supplementary Table S3). However, no other associations were found between PE teachers' demanding or domineering approaches and students' motivation (see Table 3).

Table 1. Class-level descriptive statistics and Pearson correlations of the study variables.

Variable	N	Mean (SD)	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
1. Autonomy support	79	1.80 (0.46)	.77**	.85**	.39**	.46**	.24*	-.50**	-.39**	-.51**	-.40**	-.52**	-.06	.03	.05	.01	-.09	-.13	-.26*	-.02
2. Participative	79	0.83 (0.50)	-	.32**	.26*	.31**	.16	-.21	-.16	-.22	-.14	-.16	-.06	-.20	-.10	.16	.05	.05	-.30**	.02
3. Attuning	79	2.77 (0.62)	-	-	.37**	.44**	.22*	-.57**	-.44**	-.58**	-.47**	-.64**	-.05	.20	.15	-.11	-.17	-.23*	-.14	-.06
4. Structure	79	1.93 (0.48)	-	-	-	.91**	.90**	-.11	.01	-.02	-.70**	-.47**	-.67**	.04	.10	-.06	-.14	-.16	.03	.09
5. Guiding	79	1.43 (0.54)	-	-	-	-	.63**	-.13	-.04	-.02	-.64**	-.48**	-.55**	.04	.03	-.05	-.09	-.03	-.02	.06
6. Clarifying	79	2.43 (0.51)	-	-	-	-	-	-.07	.04	-.16	-.63**	-.36**	-.67**	.04	.15	-.07	-.16	-.27*	.07	.11
7. Control	79	0.77 (0.35)	-	-	-	-	-	-	.90**	.91**	.38**	.54**	.02	-.18	-.01	.34**	.37**	.19	.23*	.06
8. Demanding	79	0.73 (0.38)	-	-	-	-	-	-	-	.64**	.25*	.41**	-.06	-.26*	.01	.32**	.27*	.10	.27*	-.04
9. Domineering	79	0.81 (0.40)	-	-	-	-	-	-	-	-	.44**	.56**	.10	-.08	-.01	.30**	.41**	.25*	.14	.14
10. Chaos	79	0.51 (0.37)	-	-	-	-	-	-	-	-	-	.84**	.74**	-.20	-.23*	.09	.22	.29*	.02	-.04
11. Abandoning	79	0.58 (0.51)	-	-	-	-	-	-	-	-	-	-	.27*	-.30**	-.26*	.10	.22	.36**	.06	.01
12. Awaiting	79	0.44 (0.41)	-	-	-	-	-	-	-	-	-	-	-	.01	-.09	.03	.12	.08	-.03	-.07
13. Intrinsic motivation	79	3.73 (0.38)	-	-	-	-	-	-	-	-	-	-	-	-	.74**	.08	-.08	-.39**	.30**	-.07
14. Identified regulation	79	3.28 (0.34)	-	-	-	-	-	-	-	-	-	-	-	-	-	.35**	.16	-.40**	.23*	-.02
15. Introjected regulation	79	2.63 (0.37)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.68**	.26*	.24*	.01
16. External regulation	79	2.21 (0.36)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.62**	.06	.10
17. Amotivation	79	2.15 (0.41)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.13
18. In-class MVPA %	77	54.70 (14.70)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-.49**
19. In-class sedentary behaviour%	77	6.00 (9.01)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

MVPA: moderate-to-vigorous-intensity physical activity; %, percentage of physical education lesson.
 * $p < .05$, ** $p < .01$.

Table 2. Variance at class and student level of the student outcomes.

Variable	Variance situated at the class level (level 2, teacher/class)	Variance situated at the student level (level 1)
Intrinsic motivation	.08	.92
Identified regulation	.07	.93
Introjected regulation	.04	.96
External regulation _a	.03	.97
Amotivation	.09	.91
In-class MVPA %	.60	.40
In-class sedentary behaviour %	.60	.40

MVPA: moderate-to-vigorous-intensity physical activity; %: percentage of physical education lesson.

^aIt is important to note that for external regulation a two-level model was not significantly better than a one-level model, with class-level variance not reaching significance.

Furthermore, PE teachers' observed chaotic style related negatively to intrinsic motivation ($\beta = -.11, p = .02$), with only PE teachers' abandoning approach revealing this association ($\beta = -.13, p = .01$). Several abandoning behaviours related negatively to students' intrinsic motivation (see Supplementary Table S3). However, no other associations were found between PE teachers' abandoning or awaiting approaches and students' motivation (see Table 3).

Relation between PE teachers' observed (de)motivating teaching and students' in-class MVPA and sedentary behaviour (H2). Most of the variance of MVPA and sedentary behaviour was situated at the class level (i.e. 60%, see Table 2). Contradictory to H2a, neither PE teachers' observed autonomy-supportive nor PE teachers' observed structuring styles or approaches related to students' MVPA and sedentary behaviour (see Table 3). PE teachers' observed demanding approach related positively to MVPA ($\beta = .21, p = .03$). Specifically, when PE teachers were observed to put pressure on students to meet certain deadlines ($\beta = .22, p = .02$), students' in-class MVPA increased. Contradictory to H2b, no other associations were found between PE teachers' observed demotivating styles or approaches and in-class MVPA and sedentary behaviour (see Table 3).

Indirect relations between PE teachers' observed (de)motivating teaching and students' in-class MVPA and sedentary behaviour through student motivation (H3). Only PE teachers' observed demanding approach showed a significant association with MVPA, students' intrinsic motivation, and introjected regulation (see above). As such, a two-level path analysis was conducted from PE teachers' demanding approach to in-class MVPA through intrinsic motivation and introjected regulation. This two-level path model yielded a moderate to good fit (CFI = .99, TLI = .76, RMSEA = .04, SRMR_{within} = .01, SRMR_{between} = .03). Table 4 and Figure 2 show that PE teachers' demanding approach might have a negative indirect effect on students' in-class MVPA, as a demanding approach was negatively related to intrinsic motivation ($\beta = -.27, p = .01$), and intrinsic motivation ($\beta = .18, p < .01$) was positively related to students' MVPA.

Table 3. Standardized linear mixed-effects models between PE teachers' (de)motivating teaching and student outcomes.

Variable	Intrinsic motivation	Identified regulation	Introjected regulation	External regulation _a	Amotivation	In-class MVPA %	In-class sedentary behaviour %
Autonomy support	.07 (.04)	.04 (.04)	.01 (.04)	.01 (.04)	-.01 (.05)	-.14 (.08)	.03 (.09)
Participative	-.01 (.04)	.01 (.04)	.06 (.04)	.06 (.04)	.06 (.05)	-.10 (.08)	.01 (.09)
Attuning	.12 (.04)*	.06 (.05)	-.05 (.04)	-.05 (.04)	-.06 (.05)	-.14 (.09)	.04 (.09)
Structure	.05 (.04)	.04 (.04)	-.02 (.04)	-.04 (.04)	-.05 (.05)	.01 (.09)	.06 (.09)
Guiding	.03 (.04)	.01 (.04)	-.03 (.04)	-.03 (.04)	-.01 (.05)	-.06 (.09)	.07 (.10)
Clarifying	.06 (.04)	.07 (.04)	-.01 (.04)	-.04 (.04)	-.10 (.05)	.06 (.09)	.05 (.09)
Control	-.09 (.04)	-.01 (.05)	.13 (.04)	.11 (.04)	.03 (.05)	.16 (.09)	.01 (.10)
Demanding	-.11 (.04)*	-.01 (.04)	.14 (.04)*	.09 (.04)	.02 (.05)	.21 (.09)*	-.07 (.10)
Domineering	-.05 (.04)	-.01 (.04)	.09 (.04)	.11 (.04)	.04 (.05)	.08 (.08)	.07 (.09)
Chaos	-.11 (.05)*	-.09 (.04)	.01 (.04)	.06 (.04)	.11 (.05)	.07 (.08)	-.04 (.09)
Abandoning	-.13 (.04)*	-.08 (.05)	.03 (.04)	.05 (.04)	.13 (.05)	.14 (.09)	-.05 (.10)
Awaiting	-.04 (.05)	-.05 (.05)	-.01 (.05)	.05 (.04)	.03 (.05)	-.03 (.08)	-.01 (.10)

PE teachers' (de)motivating styles and approaches were included separately in the models and not all together, but the p-value was adjusted relying on the Benjamini-Hochberg (BH) procedure (see 2.5 analyses). All analyses were controlled for the lesson topic, and students' sex and age.

^aIt is important to note that for external regulation a two-level model was not significantly better than a one-level model, with class-level variance not reaching significance

MVPA: moderate-to-vigorous-intensity physical activity, %: percentage of physical education lesson.

*p < .05.

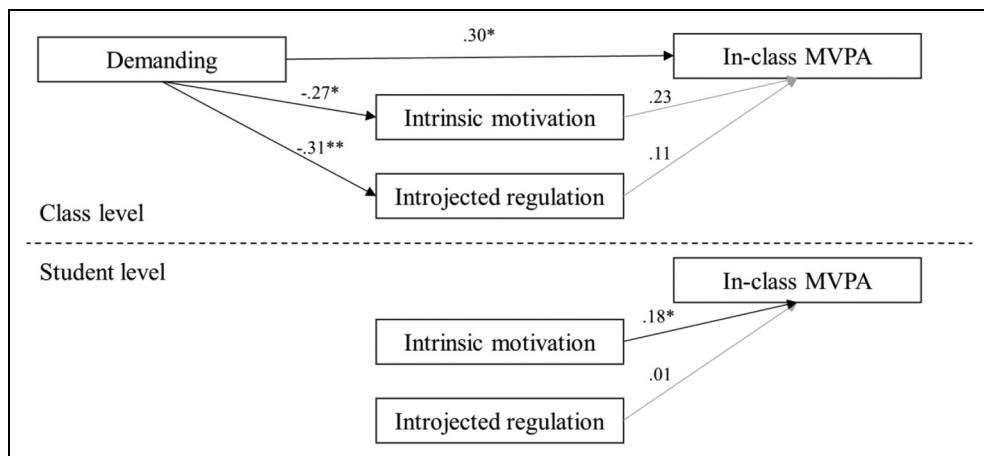
Table 4. Two-level path analysis: PE teachers' demanding approach, intrinsic motivation, introjected regulation, and in-class MVPA.

Student-level	Class-level				
	MVPA% β (SE)		MVPA% β (SE)	Intrinsic motivation β (SE)	Introjected regulation β (SE)
Intrinsic motivation	.18 (.03)**	Intrinsic motivation	.23 (.14)		
Introjected regulation	.01 (.04)	Introjected regulation	.11 (.11)		
Students' sex	-.33**	Demanding approach	.30 (.11)**	-.27 (.11)*	.31 (.09)**
Students' age	-.07 (.09)	Lesson topic: artistic sports	-.26 (.11)*	-.33 (.13)**	-.13 (.13)
Residual variance	.85 (.04)**	Lesson topic: fitness and track	-.32 (.17)	-.20 (.12)	-.05 (.12)
		Lesson topic: racket games	.02 (.08)	-.10 (.11)	-.18 (.12)
		Residual variance	.72 (.10)**	.85 (.08)**	.87 (.07)**

The lesson topic was compared against the reference group ball games.

MVPA: moderate-to-vigorous-intensity physical activity; %: percentage of physical education lesson.

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

**Figure 2.** Visual representation of the two-level path analysis.

Black lines indicate a significant association, while grey lines indicate a non-significant association. For clarity, associations with the control variables (students' sex and age at the student level and the lesson topic at the class level) have not been included. Model fit: CFI = .99, TLI = .76, RMSEA = .04, SRMR_{within} = .01, SRMR_{between} = .03. MVPA: moderate-to-vigorous-intensity physical activity; CFI = comparative fit index; TLI = Tucker–Lewis index; RMSEA = root-mean-square error of approximation; SRMR = standardized root-mean-square residual. * $p < .05$, ** $p < .01$.

Discussion

This study examined how PE teachers' actual behaviour relates to students' motivation, in-class MVPA, and sedentary behaviour. Observations revealed that PE teachers' attuning approach related positively, while their demanding and abandoning approaches related negatively, to students' intrinsic motivation. If the goal of PE is to foster intrinsic motivation, an attuning approach should be promoted, while demanding and abandoning approaches are to be avoided. Further, a dual pathway was found for a demanding approach, directly increasing in-class MVPA but indirectly reducing in-class MVPA by decreasing intrinsic motivation. These findings contribute to the ongoing debate on the goals of PE and how these relate to teachers' (de)motivating teaching.

PE teachers' observed (de)motivating teaching and student motivation

PE teachers' observed attuning approach positively related to intrinsic motivation, specifically when teachers were observed as providing students with enjoyable and innovative activities. This aligns with previous research using observations (Van Doren et al., 2023).

However, a participative approach, the second approach of autonomy support, did not relate to students' motivation. It is important to note that a participative approach was rarely observed ($M = 0.83$, $SD = 0.50$, Table 1). Furthermore, a key aspect of a participative approach is providing choices. Prior studies suggest that choice is only motivating when personally relevant (Patall et al., 2010) and not overwhelming (Schwartz, 2009), indicating that a participative approach lies closely to an awaiting approach (Escriba-Boulley et al., 2021) and may only be beneficial under certain conditions. Future research is needed to investigate when a participative approach is beneficial, preferably in a sample of teachers that is more participative.

When considering the composite score of autonomy support, encompassing the attuning and participative approach, no associations were found with students' motivation, which is similar to other research using observations (e.g. Teraoka et al., 2023). This may be because attuning and participative approaches are combined into autonomy support.

As expected, PE teachers' demanding and abandoning approaches related negatively to students' intrinsic motivation, specifically when teachers were observed to pressure students to meet deadlines (i.e. demanding behaviour), lose patience, neglect unmotivated students, give up, and not adjust their approach (i.e. abandoning behaviours). While previous studies using observations (e.g. De Meyer et al., 2014; Van Doren et al., 2023) found no associations between demotivating teaching and intrinsic motivation, these studies and numerous student-reported studies (see Vasconcellos et al., 2020 for a review; Burgueño et al., 2024; Leo et al., 2023; Tilga et al., 2023) indicated that demotivating teaching is particularly related to students' controlled forms of motivation and amotivation. Yet, in this study only the demanding approach related positively to introjected regulation. Although correlations pointed towards a positive association between PE teachers' control (i.e. demanding and domineering) and external regulation, and between PE teachers' chaos (i.e. abandoning) and amotivation, these associations did not hold in the two-level linear fixed-effects models controlled for lesson topic, and students' sex and age.

Despite the low frequency of demotivating behaviours, this study and previous studies using observations (De Meyer et al., 2014; Van Doren et al., 2023) found associations with student motivation. This suggests that students may be highly sensitive to these behaviours. The videos collected in this study offer an opportunity for future qualitative research to further understand this sensitivity.

Overall, the present study using observations found fewer significant associations compared to student-reported studies (e.g. Behzadnia et al., 2023; Leo et al., 2023; Tilga et al., 2023), aligning with studies showing limited convergence between observations and student perceptions (e.g. Van Doren et al., 2023). Several factors can explain this limited convergence. First, student perceptions reflect their overall experience with their PE teacher, while observations capture specific teaching behaviour in one lesson (Haerens et al., 2013). Second, teachers interact differently with students, whereby perceptions can differ (Sarrazin et al., 2006), while observations assess overall teacher class behaviour. Additionally, student perceptions might exhibit higher predictive power to student motivation compared to observations (De Meyer et al., 2014; Haerens et al., 2013), because student-reports use the same source for both predictor and outcome measures (Podsakoff et al., 2003). Future studies could gather multi-informant data to investigate this further (i.e. using the SIS-PE and SIS-PE-Coder; Escriva-Boulley et al., 2021; Van Doren et al., 2023).

PE teachers' observed (de)motivating teaching and students' in-class MVPA and sedentary behaviour

No associations were found between PE teachers' observed motivating styles or approaches and students' in-class MVPA or sedentary behaviour. While this aligns with previous cross-sectional studies based on student-reports (Van Doren et al., 2021), intervention studies have shown that improving PE teachers' motivating styles can increase in-class MVPA and reduce sedentary behaviour (Ha et al., 2020; Lonsdale et al., 2019). This might imply that a certain threshold of motivating behaviours might be needed to impact in-class MVPA and sedentary behaviour. For instance, PE may need to be more participative (e.g. providing choice) (Lonsdale et al., 2013).

Additionally, the lack of associations between motivating styles and in-class MVPA contrasts with previous research linking student-reported motivating styles to students' leisure-time physical activity (e.g. Kalajas-Tilga et al., 2020). This discrepancy could stem from differences in measurement methods (observed vs. perceived styles) or in varying effects of these styles on in-class versus leisure-time physical activity. Future studies are needed to investigate this further.

Interestingly, although a chaotic style showed no association with in-class MVPA, one abandoning behaviour (i.e. neglecting unmotivated students) was positively related to in-class MVPA. This may indicate that students increase their activity to gain attention from teachers who focus only/more on engaged students (Skinner and Belmont, 1993).

Furthermore, this study found a significant positive association between PE teachers' observed demanding approach and in-class MVPA, suggesting that demanding teachers increase students' activity by pressuring them with deadlines. However, this contrasts a negative association between student-reported controlling style and in-class MVPA (Van Doren et al., 2021). This indicates a potential dual pathway of a demanding approach and its different short-term and prolonged effects. While a demanding approach may have a direct positive effect on in-class MVPA in the short term, prolonged exposure to demanding behaviours could indirectly reduce in-class MVPA by undermining students' intrinsic motivation. Thus, although a demanding approach may seem effective for increasing in-class MVPA in the short term, it ultimately harms students' intrinsic motivation and likely adversely affects in-class MVPA in the long term (Bartholomew et al., 2018). This finding provides important insights related to PE's goals. While promoting in-class MVPA is important (Sallis et al., 2012), fostering students' motivation to the benefit of all

PE-related goals including lifelong engagement in physical activity is crucial (Hagger and Chatzisarantis, 2016). A demanding approach that increases short-term activity but undermines intrinsic motivation may be counterproductive to this broader aim. Future research should explore strategies that balance these competing goals, identifying behaviours that simultaneously enhance in-class MVPA and students' motivation.

Practical implications

Based on the current findings, it appears beneficial to train PE teachers to become more motivating and less demotivating. More specifically, PE teachers can try to enhance certain attuning behaviours (i.e. offering fun and innovative activities), while simultaneously diminishing specific demanding (i.e. putting pressure to meet certain deadlines) and abandoning behaviours (i.e. being irritated, not caring about unmotivated students, giving up on students, and not adjusting their approach).

Another recommendation pertains to the approach PE teachers should adopt when aiming to increase in-class MVPA. While a demanding approach may seem suitable, we refrain from recommending this due to its negative association with intrinsic motivation, which, in turn, positively related to in-class MVPA. PE has many other goals beyond increasing in-class MVPA, such as developing students' motor and social competencies and promoting a healthy lifestyle (Haerens et al., 2016). A demanding approach may undermine these goals. For instance, students' motivation for PE serves as an antecedent of their leisure-time physical activity (Hagger and Chatzisarantis, 2016). Students taught by a motivating PE teacher show increased leisure-time physical activity levels (Kalajas-Tilga et al., 2020), while those taught by a demotivating teacher show decreased activity levels (Koka et al., 2019).

Limitations and future research

The study's cross-sectional design limits conclusions about the direction of associations. Future research should use multiple assessments throughout the year or intervention studies (e.g. Cheon et al., 2020) to explore causality. Additionally, incorporating qualitative measures, such as interviews with students about videos of PE teachers, could provide deeper insights. Relying solely on observations to assess PE teachers' (de)motivating style may fail to capture the full complexity of student-teacher interactions. Combining observations with student-reports and teacher-reports could offer a more nuanced understanding of how PE teachers' (de)motivating styles impact student outcomes. By triangulating data, consistencies and discrepancies between observed behaviours, student perceptions, and teacher intentions can be investigated. The study also faced issues with internal consistency for the participative ($\alpha = .57$) and demanding ($\alpha = .55$) approaches, with the latter being lower compared to prior research (demanding = .65, Van Doren et al., 2023). Importantly, this discrepancy cannot be solely attributed to the inclusion of the 'new' demanding behaviour, 'applying external pressure by using sanctions or rewards', as the internal consistency was even lower when this item was excluded ($\alpha = .54$). Results regarding these approaches should be interpreted with caution and future research should improve the SIS-PE-Coder by revising these items.

Another limitation is that 12.4% of the students did not wear an accelerometer, potentially affecting the representativeness of the in-class MVPA and sedentary behaviour measurements. However, accelerometers were distributed randomly to minimize bias, and a large proportion of students (87.6%) wore them.

Given the ongoing debate regarding the trade-off between focusing on increasing in-class MVPA and fostering motivation during PE (e.g. Haerens et al., 2016), our focus was directed towards these outcomes. Future research should include other outcomes such as students' motor competencies, social skills, and their (intentions to engage in) leisure-time physical activity.

All predictors (i.e. four styles, eight approaches, and 43 behaviours) were included separately in the linear mixed-effects models. Despite using the BH-procedure to manage multiple comparisons, it would be better to include all predictors simultaneously to assess their unique contribution and to reduce type I errors. However, due to multicollinearity, this was not feasible as it resulted in statistical artefacts.

Lastly, the multilevel path model was limited to constructs that showed preliminary associations due to the relatively small sample size. Moreover, to explore mediation effectively, longitudinal data with a minimum of three time points are necessary. Future research should investigate multi-level mediation models involving all PE teachers' (de)motivating styles, types of motivation, in-class MVPA, and sedentary behaviour.

Conclusion

This study found that PE teachers' observed attuning approach positively related to students' intrinsic motivation, while demanding and abandoning approaches related negatively. The demanding approach also positively related to students' introjected regulation. Although PE teachers' observed demanding approach was positively associated with in-class MVPA, it negatively related to intrinsic motivation, which, in turn, related to decreased in-class MVPA. As such, the use of a demanding approach might ultimately be harmful to in-class MVPA. Future research is needed to determine how this approach and other approaches impact the broader goals of PE (e.g. developing motor and social competencies, and promoting a healthy lifestyle).

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Author contributions

Conceptualization: N.V.D., S.C., L.Ha., and K.D.C.; data curation: N.V.D., S.C., A.B., L.Ha., and K.D.C.; formal analysis: N.V.D., A.B., L.He., T.S., and M.S.; funding acquisition: S.C. and K.D.C.; investigation: N.V.D., S.C., A.B., L.Ha., and K.D.C.; methodology: N.V.D., S.C., A.B., L.Ha., and K.D.C.; project administration: N.V.D., S.C., L.Ha., and K.D.C.; resources: S.C., L.Ha., and K.D.C.; software: A.B. and M.S.; supervision: S.C., L.Ha., and K.D.C.; validation: N.V.D. and L.He.; visualization: N.V.D.; writing – original draft: N.V.D.; writing – review and editing: all co-authors. All authors have read and agreed to the published version of the manuscript.

Consent to participate

PE teachers and students signed informed consent forms online. School board members and parents or legal guardians signed paper forms. All forms were signed before data collection.

Consent for publication

The above-mentioned informed consent forms also included consent for publication.

Data availability

Data from this study are confidential and not publicly available due to informed consent restrictions. Data are stored securely on password-protected servers following the ethical guidelines from the Committee for Medical Ethics.

Declaration of conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.


Ethical considerations


The study followed the guidelines of the Declaration of Helsinki and the guidelines for good clinical practice (ICH/GCP). The study was approved by the Committee for Medical Ethics at UZ Ghent (BC-08933).

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Supplemental material

Supplemental material for this article is available online.

Notes

1. <https://pypi.org/project/pygt3x/>
2. <https://pypi.org/project/agcounts/>

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