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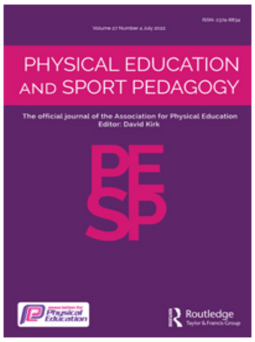

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The importance of satisfying children's basic psychological needs in primary school physical education for PE-motivation, and its relations with fundamental motor and PE-related skills

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ABSTRACT

Background: Motivation for physical education (PE) is considered an important factor for the development of children's physical skills during PE. According to self-determination theory, satisfaction of the psychological needs of autonomy, relatedness, and competence is related to higher levels of autonomous motivation, and lower levels of controlled motivation. To get a better insight into these relations, the present study examines whether satisfaction of the psychological needs is predictive of fundamental motor skills (FMS) and PE-related skills, both directly, and indirectly (via motivation, i.e. 'the motivational sequence'). As PE-related skills are more representative to the skills that are generally practiced during PE, the strongest relations are expected for these types of skills.

Method: In this study, 2224 children (51.6% boys, mean age 11.8 ± 0.55) of 89 primary schools filled out questionnaires assessing the satisfaction of their basic psychological needs and their motivation for PE. Using a block design, FMS were assessed using standardized tests, and a diverse set of PE-related skills that are explicitly practiced during PE-lessons were tested using valid and reliable tests. Structural equation models were built in Mplus to examine the hypothesized relations.

Results: Competence, peer-relatedness, and teacher-relatedness were predictive of autonomous motivation, whereas only peer-relatedness was predictive of controlled motivation. Different relations with psychological needs and motivation were found for FMS and PE-related skills. Autonomous and controlled motivation predicted PE-related skills, whereas only controlled motivation predicted FMS, in both cases via direct and indirect paths. In addition, direct relations were found between competence and both FMS and PE-related skills, and of peer-relatedness and teacher-relatedness with FMS specifically.

Conclusions: Satisfaction of the psychological needs seems important for children's PE-motivation and for their skill development, both directly and indirectly. These results underline the important role that PE-teachers play in constructing a need-satisfying environment. The motivational sequence seems to be more applicable to PE-related skills than to FMS, showing that is important to choose adequate outcome measures when examining PE-motivation.

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Introduction

The importance of physical education (PE) for children's physical, affective, and social development is widely recognized (Gallahue and Donnelly 2007). PE is considered the main environment for children to be physically active, thereby being important for children's physical fitness and health (Bailey 2016). In addition, one of the core goals of PE is helping children to develop adequate levels of fundamental motor skills (FMS) (Kirk 2005). Importantly, children who are more motivated for PE put in more effort and participate at higher intensity levels, thereby also greatly increasing the extent to which children develop new skills (Reeve 2012). Yet, it seems that levels of PE-motivation already decline between grades 4 and 6 (Chanal et al. 2019; Xiang, McBride, and Guan 2004). It is of vital importance to get a better understanding of the processes that determine whether children see PE as a valuable and enjoyable experience. Therefore, the present study will investigate the processes determining children's PE-motivation, by examining to what extent satisfaction of children's psychological needs is predictive of PE-motivation, and to what extent PE-motivation subsequently predicts children's physical skills.

We will examine two categories of physical skills, namely FMS and PE-related skills. FMS can be defined as 'basic, learned motor patterns that do not occur naturally' (Barnett et al. 2016, 221), which are needed for the development of more complex movement skills that facilitate successful participation in physical activities (Stodden et al. 2008). FMS can be further subdivided into locomotor skills (e.g. running and jumping) and object-control skills (e.g. throwing and catching). With PE-related skills we refer to a wide variety of skills that are developed and used during engagement in PE-activities, and that are needed for a lifelong physically active lifestyle (Mooij et al. 2011).

Self-determination theory

Most research on motivational processes during PE (Van den Berghe et al. 2014) has used the Self-Determination Theory framework (SDT; Deci and Ryan 1985). According to SDT, motivation lies on a continuum from extrinsic to intrinsic motivation via introjected, identified, and integrated motivation. Extrinsic motivation and introjected motivation are considered more controlled forms of motivation, which are characterized by behaviors that are performed for the sake of an external goal. Identified motivation, integrated motivation, and intrinsic motivation are more autonomous forms of motivation, characterized by behavior that is performed with the experience of freedom. Although motivation is often seen as a continuum, studies have shown that controlled and autonomous motivation are independent constructs (see Wang et al. 2016). In the domain of PE, controlled forms of motivation have been associated with maladaptive outcomes in the behavioral (e.g. fewer intentions to be physically active during leisure time, lower activity levels), cognitive (e.g. lower concentration), and affective (e.g. boredom, unhappiness) domains (Ntoumanis and Standage 2009). Autonomous motivation has been related to higher levels of these outcomes (see Van den Berghe et al. 2014). Importantly, associations have also been found between autonomous PE-motivation and locomotor skills, balance skills (Kalaja et al. 2009) and gymnastic performance (Boiché et al. 2008) of adolescents, indicating that motivation is an important factor in determining how effective PE will be for developing physical skills.

According to SDT, three basic psychological needs have to be satisfied in order for autonomous motivation to arise: autonomy, competence, and relatedness (Deci and Ryan 1985). Autonomy refers to an individual's feeling of being in control when carrying out activities. Competence entails an individual's perception of his or her own ability to accomplish certain tasks. Relatedness refers to the feeling of being accepted by, and connected with others. In adolescents it has already been found that satisfaction of the basis psychological needs during PE lessons is related to their PE-motivation (Cox, Smith, and Williams 2008; Ntoumanis 2005; Standage, Duda, & Ntoumanis 2003). Yet, only few studies have examined these relations in primary school children (Van Aart et al. 2017) and most studies do not include all basic psychological needs and both autonomous and controlled forms of motivation (Huhtiniemi et al. 2019). This is unfortunate, as primary school is a crucial period for children to develop motor skill proficiency (Hardy et al. 2012; Stodden et al. 2008).

A motivational sequence

Vallerand, Fortier, and Guay (1997) proposed a motivational sequence according to which satisfaction of the basic psychological needs influences motivation, which in turn brings about affective, cognitive, and behavioral outcomes. Applying this motivational sequence to the PE context suggests that satisfaction of a child's need for autonomy, competence, and relatedness during PE-lessons, is related to higher levels of autonomous motivation, lower levels of controlled motivation, and subsequently to better behavioral outcomes, such as the development of physical skills. Additionally, it is assumed that the need for competence is not only indirectly, but also directly related to FMS (van Aart et al. 2015). In line with this assumption, direct relations between perceived competence and locomotor skills (Kalaja et al. 2009) and object-control skills (Barnett et al. 2011) have been found. It has to be noted that perceived motor competence and satisfaction of the need for competence, although closely related, cannot necessarily be equated. Perceived competence refers to children's perception of their actual level of motor competencies (Harter 1999) and is a more narrow concept than satisfaction of the need for competence, referring to the desire to seek out challenges and activities to experience and develop feelings of competence (Legault 2017). The need for competence is influenced by a wider range of contextual factors, such as the complexity of exercises or the teachers' motivating style (De Meester 2017). The direct relations between perceived competence and FMS that have been found thus suggest that direct relations between the need for competence and FMS can be expected, but direct evidence is needed to confirm this relation.

Although evidence for relations between psychological need satisfaction and PE-motivation; and between PE-motivation and motor outcomes has been found (see Vasconcellos et al. 2020, for a meta-analysis), to our knowledge there is only one study that examined the complete motivational sequence in which the three concepts of need satisfaction, motivation, and motor outcomes are combined. Van Aart and colleagues (2015) investigated this motivational sequence in PE and found that the satisfaction of all three basic psychological needs was positively related to autonomous PE-motivation, but not to controlled PE-motivation. Contradictory to their expectations, no significant relations were found with FMS, neither for psychological needs, nor for PE-motivation.

Still, this result does not necessarily mean that the motivational sequence does not hold for the domain of PE, because the study by Van Aart and colleagues (2015) focused solely on FMS as outcome measure. It can be questioned whether the standardized tests used to measure FMS (such as the Bruininks-Oseretsky Test of Motor Profiency 2; BOT-2; Bruininks and Bruininks 2005), despite being reliable, valid, and widely used, provide a good representation of the skills that children typically acquire during PE-lessons. Since motivation is believed to be partially based on earlier experiences (Moy, Renshaw, and Davids 2016), children's PE-motivation may be more strongly linked to skills and exercises that are directly practiced during PE. In Dutch PE, children are taught to participate in a broad range of physical activities (e.g. climbing, swinging, aiming, and games such as tag games and ball games), so that they can build up a large variety of physical skills, and are prepared for a lifelong physically active lifestyle (Mooij et al. 2011). Although FMS are important to engage in these physical activities, they cannot necessarily be equated to more PE-related skills. Recently, Bonney and Smits-Engelsman (2019) suggested to take the difference between isolated FMS (such as measured with the BOT-II by van Aart and colleagues) and more ecological valid PE-skills into account. This differentiation between two sets of skills might also explain why no significant correlation between PE-motivation and FMS was found in the study by Van Aart and colleagues (2017). Following this rationale, PE-motivation can be expected to be more strongly linked to the skills directly needed to engage in PE-activities (i.e.: PE-related skills).

The present study

To get more insight into the applicability of Vallerand's motivational sequence to PE, the present study examines the motivational sequence using two different physical outcome measures in children of grade 6 of Dutch primary school. Adding to previous literature (see Vasconcellos et al. 2020), all three basic psychological needs and both autonomous and controlled motivation will be examined and related to the two physical outcomes. More specifically, it will be examined whether: (1) satisfaction of the three basic psychological needs predicts autonomous and controlled PE-motivation, (2) whether autonomous and controlled PE-motivation are subsequently predictive of PE-related skills and FMS, and (3) whether these relations differ depending on the physical skills assessed. We expect stronger relations for skills that are explicitly taught during PE-lessons compared to FMS, as motivation is partly based on earlier experiences (in this case skills explicitly taught during PE; Moy, Renshaw, and Davids 2016), and the type of skills that children practice during PE are different from pure FMS (Mooij et al. 2011). In addition, the direct relations between the psychological needs and PE-related skills and FMS will be examined, with the hypothesis of a direct association between competence and physical skills (Barnett et al. 2011; Kalaja et al. 2009; Van Aart et al. 2017). Although SDT only presents one relatedness-construct, we separate this construct into teacher-relatedness and peer-relatedness, as previous studies have found that support from teachers and peers uniquely contributes to PE-motivation (Gairns, Whipp, and Jackson 2015). Therefore, we added teacher-relatedness and peer-relatedness as distinct predictors.

Results of our study will give more insight into the relationships between different aspects of needs-satisfaction, motivation and physical skills. This is of importance for better awareness and new approaches for teachers and teacher educators, as they will need skills and strategies to develop engaging PE environments in which children's motivation is optimally sparked.

Materials and methods

Participants

Participants were sampled using stratified multistage cluster sample, which is representative of Dutch (special) primary schools and grade 6 students (Timmermans et al. 2017). For the regular primary schools, the percentage of students whose parents were lowly educated and school size were the stratification variables. A separate sample was drawn for special primary schools. Special primary schools fall under the same regulations as regular primary schools, but they cater for students with mild learning or behavioural problems, have smaller classes and can offer the students more specialized support. Besides a main sample two samples of reserve schools were drawn so a similar substitute school could be contacted if a school from the main sample declined to participate. Within schools only grade 6 students were sampled.

Contacting the schools consisted of multiple stages. First, the schools and associated school boards received a letter and a folder explaining the goal of the study. Thereafter, schools from the main sample were contacted by phone. If schools agreed to participate the quality manager visited the school in person to investigate whether all materials necessary for the tests were available at the school location, make arrangements for consent forms to be sent to the students' parents, and answer questions of the school staff. The quality manager remained the contact person for the school for the duration of the study. Of the main sample 52% of the schools agreed to participate. In total, 2224 children (51.6% boys) of 69 primary schools and 20 special primary schools participated in this study. The participating children had a mean age of 11.8 ($SD = 0.55$), and a mean BMI of 18.5 ($SD = 3.4$).

Design

The original dataset was derived from the Dutch National Assessment of PE aimed at examining the level of Dutch primary school students' PE-related skills, physical fitness, and FMS (Timmermans et al. 2017). A large battery of physical tests was selected, based on a series of rules, that is (1) the tests had to be a combination of FMS, fitness and PE-related skills, (2) the tests needed to be administered in a standardized way and yield valid and reliable results for the sample, (3) a part of the tests needed to function as anchors to make comparisons with older national assessment, and (4) a part of the tests needed to have international standards. Based on a study on the content of Dutch PE that was conducted before the national assessment, PE-skills were selected by an external specialist and thereafter, a team of nine experts judged the selected PE-skills based on representativeness for the content of PE, in that skills should be explicitly practiced during PE-lessons.

The total battery was too time-consuming to apply to all participating children, as a time restriction of two hours was posed in which the data collection had to take place. Therefore, a block design was used, meaning that children were only tested on a selection of 5 out of the 14 skills that were tested. At each school, data collection consisted of two hours of testing. For the first hour, a block design was used to test twelve skills. An overview of the design, number of students per station and circuits is presented in Appendix 1. There were six circuits each consisting of four different stations (i.e. tests), which were, if possible, clustered based on the content of the skills measured. All tests were part of two of the six circuits. All students at the same school were tested on the same circuit, thus on the same four tests. For the second hour, a similar block design was used, but only for two tests (shuttle run test and a strategic ball game, both not included in the present study). For both the first and the second hour, the assignment of circuits (first hour) or tests (second hour) to schools was random. The application of random assignment of circuits to schools implied that the mechanism of most of the missing values in the test data was known to be random. In addition, weight and height of all children was assessed, and all children filled out student questionnaires on motivation, psychological needs, and sport participation.

Procedure

All tests were conducted in regular school hours by a team of trained research assistants, who were supervised by a quality manager to ensure that the data collection was implemented according to protocol. Physical tests were conducted during PE lessons, questionnaires were taken at either the location for the PE-lesson or in the classroom. At each school, data collection lasted approximately two school hours (90 min). Research assistants followed standardized testing protocols, on which they were trained during four half-day training sessions. Six pilot data collections were conducted before the start of the study. The first three pilot data collections were used to assess whether each circuit was feasible to administer within 90 min. The last three pilot data collections, of which two took place at regular primary schools and one in a special primary school, was conducted to assess the reliability of the measurements by having multiple observers.

Instruments and variables

Psychological needs

The Competence Autonomy classmate-Relatedness and teacher-Relatedness scale (CARR; Van Aart et al. 2017) was used to measure children's satisfaction of the needs for competence, autonomy, and relatedness specifically for PE-lessons. The CARR consists of 18 questions, making up four subscales: competence (4 items), autonomy (4 items), teacher-relatedness (6 items), and classmate-relatedness (4 items). Children answered these questions on a five point Likert scale ranging from 1 ('not at all true') to 5 ('completely true'). Test-retest reliability of the CARR is acceptable to good (Cohen's Kappa = .21 to .60). Internal consistency (Rho > .70) and validity (scalability factor $H > .40$) of all subscales is adequate (Van Aart et al. 2017), except for the autonomy subscale, which showed a marginal internal consistency and validity (Rho = .67, $H = .38$). In our sample, reliability of all subscales was considered adequate (competence, $\alpha = .78$; autonomy, $\alpha = .63$; teacher-relatedness, $\alpha = .86$; peer-relatedness, $\alpha = .82$). The scoring of the questionnaire was slightly adapted, because several children had crossed more than one answer. In these cases the average of the two answers was used as itemscore (e.g. if the answers not true (2) and true (4) were given, a score of 3 was used).

Motivation

Autonomous and controlled PE-motivation were measured with an adapted version of the Behavioral Regulations in Physical Education Questionnaire (BRPEQ: Aelterman et al. 2012; adapted version: Van Aart et al. 2017). The adapted BRPEQ consists of 12 items, making-up two subscales, autonomous motivation (7 items) and controlled motivation (5 items). All items have the same formulation, following the stem 'I put effort in this PE-class because … ,' followed by items such as ' … this PE-class is fun' (autonomous motivation), or ' … others will appreciate me less if I didn't' (controlled motivation). Children answered these questions on a five point Likert scale ranging from 1 (don't agree at all) to 5 (very strongly agree). Both subscales are considered valid (scaling factor $H > .40$), and internal consistency of the subscales is adequate (Rho > .70; Van Aart et al. 2017). In this study, reliability of both subscales was considered good (autonomous motivation, $\alpha = .87$; controlled motivation, $\alpha = .73$).

Fundamental motor skills

One subtest of the BOT-II (Bruininks and Bruininks 2005), and three subtests of the Körperkoordinationstest für Kinder (KTK; Kiphard and Schilling 1974) were conducted to measure FMS.

BOT-II. The BOT-II is a norm-referenced test battery for assessing children's fine and gross motor skills. It provides a reliable (test-retest reliability 0.80) and valid measure of children's motor proficiency (Deitz, Kartin, and Kopp 2007). In this study, only the subtest for upper-limb coordination (seven items) was used. Test-retest reliability for this subtest is good to excellent (ICC = 0.82-0.99; Wuang and Su 2009). All items include exercises with a ball, such as catching a tossed ball with both hands or bouncing. A total number of five (for five items), or ten (for two items) points per item could be reached. The number of points on the seven items was summed to get a total score, with a maximum of 45 points. For more detailed information on the scoring procedure, the interested reader is referred to the BOT-II manual (Bruininks and Bruininks 2005).

KTK. The KTK is a valid and reliable (test-retest reliability $\alpha = 0.97$) test battery to measure children's gross motor coordination (Kiphard and Schilling 1974). The original test battery consists of four subtests, of which only three (moving sideways, jumping laterally, and backwards balancing) were applied in this study. It has been previously demonstrated that this shorter version of the KTK shows substantial agreement with the original, four subtest version of the KTK ($r = 0.97$; Novak et al. 2017).

In the jumping laterally test, children stand on a mat and jump from side to side over a wooden slate placed in the middle of the mat, as quickly as possible. Two attempts are given to make as many jumps as possible within an interval of 15 s. The total number of correct jumps was summed up over the two trials. In the shifting platforms subtest, a child stands on a 25 × 25 cm platform with four legs of 3.7 cm in height, and is asked to place a second, identical platform next to the one he or she is standing on. The child steps on this second platform, replaces the first platform, and steps on the newly placed platform. One point was awarded for successfully shifting the platform, and one point for transferring the body from one platform to the next. Each child got two attempts to make as many transfers as possible. The number of points on two trials of 20 s was summed.

The balancing backwards subtest consists of three 3 m long balance beams, with decreasing widths of 6, 4.5, and 3 cm. A child walks backwards on these beams, and gets three attempts per beam to make as many steps as possible. The number of successful steps with a maximum of eight steps per attempt was recorded. This resulted in a maximum score of 24 points per balance beam, and a total maximum score of 72 for the three balance beams together.

PE-related skills

For each of the following skills information on the reliability of the measurements as derived from the pilot study is provided.

Rope swing. In this test, children make a rope swing by taking-off from a vaulting box, and have to make a half-turn before landing on a mat. Children got three attempts, of which the last two were assessed. Scores were based on: take-off (0 passive, 1 actively forwards, 2 actively upwards, 3 actively backwards), making a half-turn (0 no, 1 yes), landing on the mat (0 no, 1 yes), and stability of the landing (0 falls, 1 no stability but no fall, 2 stable). The total score was computed by adding the points on all aspects for both attempts, with a maximum of 14 points. The interobserver reliability over three observers (Kappa) in the pilot study varied between .38 (fair agreement) and 1.0 (excellent agreement), with a mean of .78.

Vaulting jump. In this test, children made a jump over a vaulting box. Four aspects were evaluated: walking over benches towards the trampoline and taking-off with two feet in the middle of the trampoline (0 no, 1 yes), placing both hands on the vaulting box and making an agile leap with both legs stretched out above the hips (0 touches the fault, 1 with bent legs low or equally high as the hips, 2 with bent legs higher than the hips, 3 with straight legs higher than the hips), landing on both feet (0 no, 1 yes), landing with the face towards the vaulting box (0 no, 1 yes). Children got four attempts, of which only the last two were evaluated. The total score was computed by adding the points for both attempts, with a maximum of 12 points. The interobserver reliability over two observers (Kappa) in the pilot study varied between −.15 (no agreement) and 1.0 (excellent agreement), with a mean of .52. Based on these results of the pilot, it was decided to have the two items related to taking-off and hand placing to be observed by a different observer than the two items related to landing, as it appeared very difficult to observe all items from one position.

Catching and throwing via the wall. In this test, children stand on a mat from which position they throw a tennis ball against the wall. They try to catch the ball when it bounces back. They do this from three different mats, the first being placed three, five and seven meters from the wall. For each mat, they got three attempts. The total number of caught balls (0 no, 1 yes) was used as a score, with a maximum of nine points. The interobserver reliability over two observers (Kappa) in the pilot study varied between .72 (substantial agreement) and 1.0 (excellent agreement), with a mean of .93.

Tennis via the wall. This test consists of two parts. First, children hit the ball 10 times against the wall above a marked line (at 1.5 m height), and return it within the field the child is standing. Second, children do the same exercise, this time with a time limit of 30 s in which they have to hit and return the ball correctly as many times as possible. For both parts, children get one point for a correctly hit ball (above the marked line), and one point for correctly returning the ball (within the field). A score was computed by adding scores on the two parts. The interobserver reliability over two observers (Pearson's correlation) in the pilot study varied between .52 (substantial agreement) and .88 (almost perfect agreement), with a mean of .71.

Aiming with a ball at a heightened target. Children were asked to aim with a ball at a basket from four different positions; right in front of the basket at two (position 1) or three (position 2) meters distance, and at two meters distance on the left (position 3) or the right side (position 4) of the basket. Children got five attempts from each position, making a total of 20 attempts. For each attempt, they either scored (2 points), hit the board (1 point), or missed (0 points). The maximum score for this test was 40 points. The interobserver reliability over two observers (Kappa) in the pilot study varied between .67 (substantial agreement) and 1.0 (excellent agreement), with a mean of .92.

Rolling on an elevated plane. Children make a forward roll on a heightened mat, after a three-meter run-up and a take-off on a springboard. Three aspects were evaluated: the first body part to touch the mat after the hands (0 head, 1 shoulders or back, 2 bottom or feet), rolling in a straight line (0 does not roll, 1 not in a straight line, 2 in a straight line), and sitting-up or standing-up after the roll (0 sitting or lying, 1 in a heel squatting position, 2 standing via a heel squatting position). Children got three attempts, of which only the last two were evaluated. A total score is computed by adding the scores on the two attempts, with a maximum of 12 points. The interobserver reliability over two observers (Kappa) in the pilot study varied between .45 (moderate agreement) and 1.0 (excellent agreement), with a mean of .76.

Balancing on an instable plane. Children walk on a bench that is hanging up-side-down in the rings on one side, and standing on the ground on the other side. They start at the side of the bench that rests on the ground, walk towards the other end, make a half-turn (0 falls, 1 with support, 2 in over 5 s without support, 3 within 5 s and without support), walking down within 4 s (0 no, 1 yes), stepping-off in a controlled way (0 no,1 yes). Children got three attempts, of which only the last two were evaluated. The total score was determined by adding the scores of both attempts, with a maximum of 12 points. The inter-observer reliability over two observers (Kappa) in the pilot study varied between .43 (moderate agreement) and 1.0 (excellent agreement), with a mean of .66.

BMI

Body Mass Index (BMI) was taken into account as covariate, because BMI is negatively related to physical fitness and motor skills (Bai et al. 2015; Benjet and Hernández-Guzmán 2002), as well as PE-motivation (Fairclough and Stratton 2006), making it likely to be an influencing variable of the proposed motivational sequence. Students' height was measured twice while in a standing position with flat heels against a wall using a seca length meter. Height was noted in cm with one decimal place. If the two measurements differed more than 0.4 cm, a third measurement was conducted. For 87.5% of the students the difference between the first two length measures was within this boundary. Students' weight was measured twice using a seca scale on a hard surface and was noted in kg with one decimal place. As for height, a third measurement was conducted if the first two results differed more than 0.4 kg. For 98.8% of the students the difference between the first two weight measures was within this boundary. An average length and height for each student was computed by taking the mean of the two (or three) measurements. Standard deviation scores for BMI (zBMI) were computed to adjust for children's age and sex, using the growth standards provided by the World Health Organization (WHO; Onis et al. 2007).

Gender and age

Gender and age were taken into account as covariates, as these have been found to have an influence on the paths between psychological need satisfaction and motivation (Ntoumanis 2001; Van Aart et al. 2017).

Data analysis

Structural equation models (SEM) were built in Mplus (Muthén and Muthén 1998–2006) using MLR estimation, to analyze the associations between the three basic psychological needs, PE-motivation, and FMS, and PE-related skills. School was added as a cluster variable to take into account the nested structure of the data. The Chi-square statistic, root mean square error of approximation (RMSEA), and comparative fit index (CFI) were used to evaluate model fit, with cut-offs of $p > .05$, .06, and .90, respectively (Hu and Bentler 1999).

Two latent variables were constructed for the physical skills. The latent factor FMS was represented by the indicators upper-limb coordination (BOT-II), moving sideways, jumping laterally, and balancing backwards (KTK). The latent factor PE-related skills was represented by the indicators rope swing, vaulting jump, catching and throwing via the wall, tennis, aiming with a ball, rolling on an elevated plane, and balancing on an instable plane.

Two models were built, one for each latent physical skill measure (FMS and PE-related skills) because of the missing value structure of the data (i.e. no participants had complete data on all of these outcome measures). Competence, autonomy, teacher-relatedness, peer-relatedness, and controlled and autonomous motivation were used as predictors of FMS or PE-related skills. Also paths between competence, autonomy, and relatedness (with teacher and peers) and autonomous and controlled motivation were added. Age, gender, and zBMI were added to the models as covariates, and related to the psychological needs, motivation, and the latent factors representing the physical skill measures. Residual covariances between controlled and autonomous motivation were added, as were covariances between the four variables representing psychological needs.

Although the data contained many missing values, the missing values were assumed to be ignorable as almost all missing values were a direct consequence of the research design. For 91.4% of the students, the pattern of missing values exactly followed the design of the study with four out of the twelve station-scores observed and no missing values in the covariates and psychological needs and motivation scales. The mechanism behind these missing values is fully known as circuits were randomly assigned to schools. For only 8.6% of the students a deviating pattern is observed, usually consisting of four out of the twelve station-scores observed and one or more missing values on the covariates or psychological needs and motivation scales. Over the entire dataset the MCAR assumption does not hold; χ^2 (2187) = 2863,484, $p < .001$. However, subsequent analyses showed that the missing values could be predicted from other variables used in this study and therefore the missing values are assumed to be MAR.

Results

Overall mean scores on basic psychological needs, autonomous and controlled motivation, and FMS and PE-related skills are presented in Table 1. Correlations between these variables, and the latent variables constructed in the models, are presented in Appendix 2. Figures presenting the models with all included pathways, factor loadings, error terms, and covariances can be found in Appendix 3.

Fundamental motor skills

A model without the indirect paths between psychological needs and FMS via motivation was not a good fit to the data, $\chi^2(37) = 1145.73$, $p < .01$, RMSEA = .12, CFI = .53, SRMR = .10, and the results were not further interpreted. A second model with added indirect paths between psychological needs and FMS via autonomous and controlled motivation, examining the motivational sequence, proved to have a good fit to the data, χ^2 (29) = 63.89, $p < .01$, RMSEA = .02, CFI = .99, SRMR = .03.

Table 1. Mean scores on psychological needs, PE-motivation, and the physical outcome measures.

Variable	*N*	Mean (*SD*)	Minimum–Maximum
Psychological needs			
Competence	2005	15.4 (2.8)	4–20
Autonomy	1906	11.1 (2.7)	4–20
Peer-relatedness	2011	15.8 (2.9)	4–20
Teacher-relatedness	2005	23.6 (4.3)	6–30
PE-motivation			
Autonomous	2001	28.8 (5.3)	7–35
Controlled	1987	9.0 (2.6)	5–25
Motor skills			
KTK moving sideways	669	41.8 (10.91)	9–82
KTK jumping laterally	625	64.7 (13.9)	19–142
KTK balancing backwards	664	39.0 (13.6)	1–72
BOT upper-limb	660	40.6 (4.0)	16–45
PE-related skills			
Rope swing	710	8.5 (2.7)	0–14
Vaulting jump	684	7.6 (2.6)	0–12
Catching and throwing	572	2.8 (2.3)	0–9
Tennis	606	26.9 (9.1)	1–51
Aiming	637	25.1 (5.1)	2–36
Rolling	636	6.5 (2.6)	0–12
Balancing instable	696	6.4 (2.7)	0–12

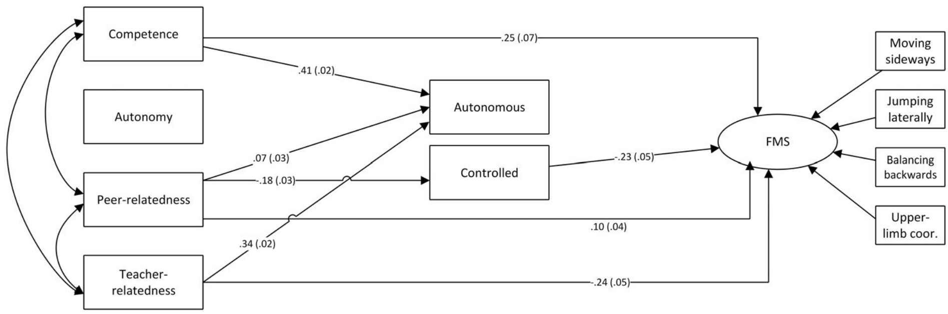

Figure 1. Significant paths among basic psychological needs, PE-motivation, and FMS, controlling for age, gender, and zBMI. Standardized path coefficients (betas) and associated standard errors are presented in the figure.

In total, 27.1% of the variance in FMS was explained by direct and indirect relations with psychological needs and PE-motivation. Significant paths in the model are presented in Figure 1.

Direct relations

Competence ($\beta = .41$ (.02), $p < .001$, 95%-CI = .36 to .45), peer-relatedness ($\beta = .07$ (.03), $p = .006$, 95%-CI = .02 to .12), and teacher-relatedness ($\beta = .34$ (.02), $p < .001$, 95%-CI = .29 to .39) were significant and positive predictors of autonomous PE-motivation. Peer-relatedness ($\beta = -.18$ (.03), $p < .001$, 95%-CI = −.23 to −.13) was a significant negative predictor of controlled motivation. Controlled motivation negatively predicted FMS ($\beta = -.23$ (.05), $p < .001$, 95%-CI = −.34 to −.13). Competence ($\beta = .25$ (.07), $p < .001$, 95%-CI = .11 to .38) and peer-relatedness ($\beta = .10$ (.04), $p = .008$, 95%-CI = .03 to .18) were significant positive predictors of FMS, whereas teacher-relatedness was a significant negative predictor of FMS ($\beta = -.24$ (.05), $p < .001$, 95%-CI = −.33 to −.15).

Gender was negatively related to autonomous motivation ($\beta = -.04$ (.02), $p = .033$, 95%-CI = −.07 to −.003), controlled motivation ($\beta = -.08$ (.02), $p < .001$, 95%-CI = −.13 to −.04), and competence ($\beta = -.18$ (.02), $p < .001$, 95%-CI = −.23 to −.13); indicating that boys were on average more motivated (both intrinsically and extrinsically) and felt more competent than girls.

Age was positively related to controlled motivation ($\beta = .12$ (.05), $p < .001$, 95%-CI = .05 to .18), and negatively related to peer-relatedness ($\beta = .08$ (.03), $p < .001$, 95%-CI = −.13 to −.03).

zBMI was positively related to controlled motivation ($\beta = .05$ (.02), $p = .02$, 95%-CI = .01 to .10) and negatively linked to competence ($\beta = -.12$ (.02), $p < .001$, 95%-CI = −.17 to −.08) and peer-relatedness ($\beta = -.06$ (.02), $p = .003$, 95%-CI = −.10 to −.02).

Indirect relations

Peer-relatedness was indirectly related to FMS via controlled motivation, $\beta = .04$ (.01), $p < .001$, 95%-CI = .02 to .06, indicating that controlled motivation was a partial mediator in the relation between peer-relatedness and motor skills.

PE-related skills

A second series of models was fitted in which PE-related skills were used as outcome. First, a model with only direct relations among psychological needs, PE-motivation, and PE-related skills was not a good fit to the data, $\chi^2(63) = 997.75$, $p < .01$, RMSEA = .09, CFI = .59, SRMR = .10 and results were not further interpreted. A second model with added indirect relations between psychological needs and PE-related skills via autonomous and controlled motivation proved to have a good fit to the data, $\chi^2(55) = 106.93$, $p < .001$, RMSEA = .02, CFI = .98, SRMR = .06. In total, 27.6% of the variance in PE-related skills was explained by direct and indirect relations with psychological needs and PE-motivation. Significant paths in the model are presented in Figure 2.

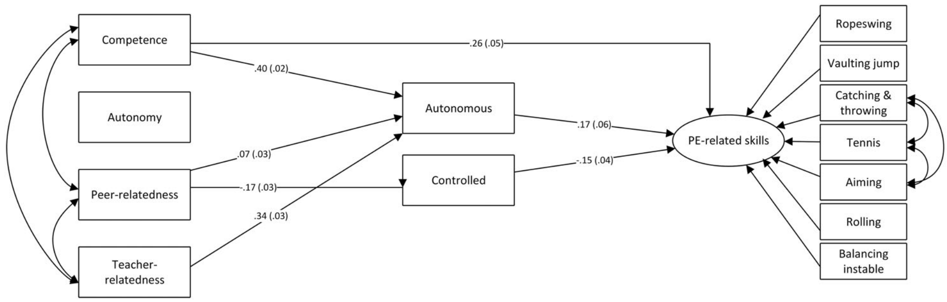

Figure 2. Significant paths among basic psychological needs, PE-motivation, and PE-related skills, controlling for age, gender, and zBMI. Standardized path coefficients (betas) and associated standard errors are presented in the figure.

Direct relations

Competence ($\beta = .40$ (.02), $p < .001$, 95%-CI = .36 to .45), peer-relatedness ($\beta = .07$ (.03), $p = .006$, 95%-CI = .02 to .12), and teacher-relatedness ($\beta = .34$ (.03), $p < .001$, 95%-CI = .29 to .39) were significant and positive predictors of autonomous motivation. Peer-relatedness ($\beta = -.17$ (.03), $p < .001$, 95%-CI = −.23 to −.12) was a significant negative predictor of controlled motivation. Autonomous motivation was a significant positive predictor of PE-related skills ($\beta = .17$ (.06), $p = .002$, 95%-CI = .06 to .28), whereas controlled motivation significantly and negatively predicted PE-related skills ($\beta = -.15$ (.04), $p < .001$, 95%-CI = −.23 to −.06). Competence was a significant positive predictor of PE-related skills ($\beta = .26$ (.05), $p < .001$, 95%-CI = .16 to .36).

Gender was significantly related to autonomous motivation ($\beta = -.04$ (.02), $p = .024$, 95%-CI = −.08 to −.01) and controlled motivation ($\beta = -.09$ (.02), $p < .001$, 95%-CI = −.14 to −.05), indicating that boys were on general more motivated for PE (both intrinsically and extrinsically) than girls. Gender was also negatively related to competence ($\beta = -.18$ (.03), $p < .001$, 95%-CI = −.22 to −.13), with boys feeling on average more competent than girls.

Age was positively related to controlled motivation ($\beta = .11$ (.03), $p = .001$, 95%-CI = .05 to .18), and negatively related to peer-relatedness ($\beta = -.06$ (.03), $p = .017$, 95%-CI = −.11 to −.01).

zBMI was negatively related to PE-related skills ($\beta = -.27$ (.04), $p < .001$, 95%-CI = −.35 to −.18), competence ($\beta = -.12$ (.02), $p < .001$, 95%-CI = −.17 to −.08) and peer-relatedness ($\beta = -.06$ (.03), $p < .017$, 95%-CI = −.10 to −.02). Also, zBMI was positively related to controlled motivation ($\beta = .05$ (.02), $p = .026$, 95%-CI = .01 to .10).

Indirect relations

Competence ($\beta = .07$ (.02), $p < .001$, 95%-CI = .03 to .12) and teacher-relatedness ($\beta = .06$ (.02), $p = .005$, 95%-CI = .02 to .10) were significantly and positively related to PE-related skills via autonomous motivation. This indicates that autonomous motivation is a partial mediator in the relation between competence and PE-related skills, and a full mediator in the relation between teacher-relatedness and PE-related skills. Peer-relatedness was significantly related to PE-related skills via controlled motivation ($\beta = .03$ (.01), $p = .004$, 95%-CI = .01 to .04), indicating that the relation between peer-relatedness and PE-related skills was fully mediated by controlled motivation.

Discussion

The aim of this study was to examine whether satisfaction of children's psychological needs was predictive of their autonomous and controlled PE-motivation, and whether this consequently differently predicted their FMS and PE-related skills (i.e. the motivational sequence). In addition, the direct relations of the psychological needs with FMS and PE-related skills were examined. Our results revealed that competence, peer-relatedness, and teacher-relatedness were all positive predictors of autonomous PE-motivation, whereas only peer-relatedness negatively predicted controlled PE-motivation. As expected, different relations were found depending on the physical skills assessed. FMS was only negatively predicted by controlled motivation, whereas both controlled and autonomous motivation predicted PE-related skills, with a negative relation of controlled motivation with PE-related skills; and a positive relation for autonomous motivation.

Only one indirect relation between psychological needs and FMS was found, namely that of peer-relatedness via controlled motivation. This same relation was found for PE-related skills, as were indirect relations via autonomous motivation, namely for competence and teacher-relatedness. In addition, direct relations among competence and both FMS and PE-related skills were found, and direct relations of peer-relatedness and teacher-relatedness with FMS specifically.

Psychological needs and PE-motivation

Our results are in line with the theoretical assumptions of the SDT and with results of previous studies using this framework (Huhtiniemi et al. 2019; Ntoumanis 2005; Standage, Duda, and Ntoumanis 2005; Van den Berghe et al. 2014), as positive relations were found between the satisfaction of the psychological needs for competence, peer-relatedness, teacher-relatedness, and autonomous PE-motivation. In order to motivate children for PE, it seems important that they are provided with a PE-environment in which their needs for competence, peer-relatedness, and teacher-relatedness are satisfied. Teachers play an important role in constructing such an environment, for example by using relatedness-supportive teaching techniques (e.g. by providing emotional support and encouraging interaction; Ntoumanis and Standage 2009); and by building students' competence levels by providing successful experiences for every child (e.g. by grouping children with the same motor skill levels, thereby maximizing the changes on success; Slingerland et al. 2014).

Unexpectedly, autonomy was not related to PE-motivation (neither autonomous, nor controlled), FMS, or PE-related skills. This result contradicts previous findings of positive relations between autonomy support and autonomous motivation, and negative relations with controlled motivation (see Vasconcellos et al. 2020, for a meta-analysis). Children of this age are generally not provided with much autonomy during PE, as teachers already make many conditional decisions based on the nature of the activities they offer, leaving few opportunities for children's initiative or leadership (McDonough and Crocker 2007; Van Aart et al. 2017). Also, PE-teachers might not be well trained or might feel uncomfortable about using more autonomy-supportive teaching styles in which they have to reduce their control over the class (Ntoumanis 2001). In line with this, students in our study reported relatively low levels of autonomy (compared to their ratings of relatedness and competence), comparable to those found in the study by van Aart and colleagues (2017) who studied a similar age group. In line with these results, a recent study on Dutch primary school students' perceptions of autonomy support revealed that children's feelings of autonomy in class are much lower than the amount of autonomy that teachers themselves report to be providing (Admiraal et al. 2019). Surprisingly, in a more recent study in Finland, autonomy ratings were similar to ratings of competence and relatedness (Huhtiniemi et al. 2019). These differences might have to do with cultural differences in PE classes, or differences in the way basic psychological needs were measured. The low levels of reported autonomy are concerning, as children who experience more autonomy may be more motivated for PE as well, consequently being beneficial for their physical skill development. It seems important to further study the effects of providing children with more autonomy, as we might otherwise miss opportunities to enhance children's motivation for PE. Feelings of autonomy can be enhanced by providing an environment where students are welcome to share their thoughts, feelings, and actions, as sensed by a teacher's non-controlling language; where students can perform tasks without feeling pressured; and where explanations are provided so that students understand the meaningfulness of participating (Reeve 2009).

Psychological needs were not in the same way predictive of autonomous compared to controlled motivation. That is, competence, peer-relatedness, and teacher-relatedness were all positively predicting autonomous motivation, whereas only peer-relatedness was negatively predicting controlled motivation. It thus seems that satisfaction of the basic psychological needs is more important for fostering autonomous motivation than for controlled motivation. This conclusion is in line with those of the meta-analysis by Vasconcellos and colleagues (2020), who found that satisfaction of the basic psychological needs was strongly related to autonomous motivation, but only weakly to more controlled forms of motivation.

PE-motivation as predictor of FMS and PE-related skills

In line with the hypothesis that motivation would be skill-specific, both autonomous and controlled motivation were found to be predictive of PE-related skills, whereas only controlled motivation was predictive of FMS. Probably, autonomous motivation was not predictive of FMS because exercises with an explicit focus on motor skills are less motivating for children than more game-based exercises such as those that were used to assess PE-related skills (Allison and Thorpe 1997; Harvey and Jarrett 2014). It has been argued that a focus on FMS performance ignores the interaction with the environment that is typical for PE and sports, as it does not matter when, why, where, and with whom these skills are executed (e.g. Cools et al. 2009). Moreover, FMS performance is not often directly implemented or assessed in Dutch PE-lessons (Van Weerden, Van der Schoot, and Hemker 2008), making it likely that children do not take into account their FMS proficiency when filling out questions about PE-motivation (Van Aart et al. 2017).

The motivational sequence

Agreeing with the study by Van Aart and colleagues (2017) the motivational sequence did not apply to FMS when examining autonomous motivation, as autonomous motivation in itself was not predictive of FMS. An indirect link was found between peer-relations and FMS via controlled motivation however. Possibly, some children feel the need to actively engage in PE in order to get recognition from their peers and to not feel isolated from their peers, meaning that they feel the pressure and obligation associated with participating in PE (a form of introjected regulation, i.e. controlled motivation; Ntoumanis 2001).

In line with our expectation that the motivational sequence would more strongly apply for skills that are explicitly taught during PE-lessons, indirect relations were found via both autonomous and controlled motivation when examining PE-related skills. Similar to FMS, peer-relatedness was predictive of PE-related skills via controlled motivation. Moreover, competence and teacher-relatedness were indirectly linked to PE-related skills via autonomous motivation. Children who feel physically competent are more likely to enjoy PE, and want to participate and put effort in it, resulting in better developed physical skills (Ntoumanis 2001). Children's relation with their teacher also seems to play a role in developing children's PE-motivation, which can consequently be beneficial for their physical skill development, underlining the important role that PE teachers play.

Psychological need satisfaction was not only indirectly, but also directly linked to physical skills. In line with our hypothesis, competence directly and positively predicted both FMS and PE-related skills, a result in line with previously found relations between perceived competence and locomotor skills and object-control skills (Barnett et al. 2011; Kalaja et al. 2009). It seems extremely important to provide all children with experiences of success during PE, as this is directly and indirectly linked to their physical skills. This can be achieved by letting children practice at their own level (Gearin and Fien 2016), making a strong case for differentiated PE-lessons where exercises are provided at different levels of mastery. Especially for children with little prior experience with sports activities this seems important, as PE is the main environment where these children will build up their feelings of competence (Papaioannou 1994). Other strategies that can be used to enhance children's competency levels are setting clear expectations and encouraging individual instead of collective effort (Almolda-Tomás et al. 2014; Taylor and Ntoumanis 2007; Tessier, Sarrazin, and Ntoumanis 2010).

Surprisingly, peer-relatedness was found to be a positive direct predictor of children's FMS, and teacher-relatedness was a negative direct predictor of FMS. Similar associations were not present for PE-related skills. The direct relation of peer-relatedness with FMS can be explained by the fact that FMS tests enable children to directly compare their own performance to that of their peers, as the focus of these tests is on a product measure (e.g. number of correct jumps) (Cale and Harris 2009). This easily creates an ego-oriented climate characterized by direct comparison and an emphasis on normative performance, which can result in anxiety due to the pressure to perform well, and consequently lower performance, especially for children who have lower-quality relations with their peers (Ames and Archer 1988; Cox, Duncheon, and McDavid 2009). It might be hypothesized that teacher-relatedness was negatively associated with FMS, because teachers possibly provide more emotional support to children with lower levels of FMS than to children who already have quite well-developed levels of FMS. However, from previous research we know that teachers tend to provide a competitive learning environment which is negatively related towards intrinsic motivation (Koka and Hein 2003). Also, if this line of argumentation would hold, we should have found a direct relation between teacher-relatedness and PE-related skills as well. As this was not the case, it remains a loose end why we found a direct negative relation between teacher-relatedness and FMS, asking for further research to find an explanation.

Strengths, limitations and research directions

Strengths of this study include the large, representative sample of Dutch primary school children that was included, the use of different test batteries to assess children's physical capacities, and the use of multilevel structural equation modelling, including multiple indicators to represent children's level of FMS and PE-related skills.

A first limitation of this study is that we could not take into account the relations between FMS and PE-related skills, as we constructed two different models for the two sets of physical skills. The block design of our study made it impossible to analyze both sets of skills in one overall model. For future studies, it remains important to take these relations between the different physical skills into account. Moreover, research on physical skills should start to focus on PE-related skills as well, because these seem to be differently related to motivation than the more typically used measure of FMS.

Second, the reliability of the autonomy subscale of the CARR has been questioned by van Aart and colleagues (2017). Although the reliability of the subscale seemed adequate in our study ($\alpha = .63$), the questionable reliability might provide an additional explanation for why autonomy was not related to any of the other constructs in our study. The items included in the autonomy subscale all refer to a concept of choice, which, as we argued before, might not be experienced by children during PE, as teachers leave few opportunities for children's initiative or leadership. Future studies should include other assessments of autonomy, such as questionnaires specifically aimed at measuring autonomy or observations, to further validate our results.

Third, it can be questioned whether the motivational sequence should be turned around, meaning that physical skills influence children's psychological need satisfaction and PE-motivation, or whether a reciprocal model might be more applicable. It is known that actual physical skills also predict feelings of motor competency (Robinson et al. 2015; Stodden et al. 2008). Yet, we chose to include physical skills as an outcome rather than as a predictor, as we are interested in ways in which children's physical skills could potentially be strengthened. We hypothesized that increasing PE motivation in a need satisfying PE environment could benefit children's physical skills, and therefore examined a model in which physical skills were used as an outcome. Ideally, we would want to examine the reciprocal relations among need satisfaction, motivation and physical skills in a longitudinal study, to get better insight into the way by which these concept influence each other.

Lastly, the relations that we find might be specific for the Dutch PE-context. In the Netherlands, PE-teachers often find positive and fun experiences in sport the most important in their lessons, thereby focusing less on children's skill development (Van Weerden, Van der Schoot, and Hemker 2008). In addition, most Dutch PE-teachers do not assess children's FMS skills in their lessons, nor do they provide a lot of autonomy for children to find their own competence levels. As a result, children are not supported in developing a realistic idea of their FMS-proficiency (Van Aart et al. 2017). Further research is needed to see whether our findings generalize to international PE settings as well.

Conclusion

This study extends the current knowledge on the applicability of SDT to primary school PE. The results confirm the important role that satisfaction of the psychological need for competence, teacher-relatedness and peer-relatedness, but not autonomy, plays in predicting children's autonomous PE-motivation. Surprisingly, only the need for peer-relatedness was related to children's controlled motivation. These results underline the importance for teachers to provide a PE environment that satisfies children's need for competence, peer-relatedness and teacher-relatedness. Children reported relatively low levels of autonomy, thus it seems important to further examine whether providing children with more autonomy results in higher levels of motivation as well.

We further provide support for the hypothesized motivational sequence, showing that peer-relatedness was indirectly linked to FMS and PE-related skills via controlled motivation; and that competence and teacher-relatedness were indirectly linked to PE-related skills specifically, via autonomous motivation. Direct relations of the psychological needs with physical skills were also present, between competence and both physical skills, and between teacher-relatedness, peer-relatedness and FMS specifically. The motivational sequence thus seems to be more applicable to physical skills that are directly targeted during PE, showing that is important to choose adequate outcome measures when examining PE-motivation. In future research attention should be given to intervention studies which try to positively influence the development of PE-related skills through the satisfaction of the psychological needs.

Overall, the results underline the important role that PE-teachers play in developing children's physical skills. By providing a need-satisfying environment, specifically targeting competence, peer-relatedness, and teacher-relatedness they can directly and indirectly (via PE-motivation) stimulate children's physical development, especially the development of their PE-related skills.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

The datasets analyzed for the current study are not publicly available due to sensitivity of the data and the restrictions from the informed consent but are available from the corresponding author on reasonable request.

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