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*Published in:*  
Mental health and physical activity

*DOI:*  
[10.1016/j.mhpa.2021.100413](https://doi.org/10.1016/j.mhpa.2021.100413)

**IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.**

*Document Version*  
Publisher's PDF, also known as Version of record

*Publication date:*  
2021

[Link to publication in University of Groningen/UMCG research database](#)

### *Citation for published version (APA):*

Mazereel, V., Vansteelandt, K., Menne-Lothmann, C., Decoster, J., Derom, C., Thiery, E., Rutten, B. P. F., Jacobs, N., van Os, J., Wichers, M., De Hert, M., Vancampfort, D., & van Winkel, R. (2021). The complex and dynamic interplay between self-esteem, belongingness and physical activity in daily life: An experience sampling study in adolescence and young adulthood. *Mental health and physical activity*, 21, [100413]. <https://doi.org/10.1016/j.mhpa.2021.100413>

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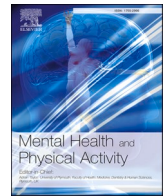
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## The complex and dynamic interplay between self-esteem, belongingness and physical activity in daily life: An experience sampling study in adolescence and young adulthood

Victor Mazereel<sup>a,b</sup>, Kristof Vansteelandt<sup>b</sup>, Claudia Menne-Lothmann<sup>c</sup>, Jeroen Decoster<sup>d</sup>, Catherine Derom<sup>e,f</sup>, Evert Thiery<sup>g</sup>, Bart P.F. Rutten<sup>c</sup>, Nele Jacobs<sup>c,h</sup>, Jim van Os<sup>c,i,j</sup>, Marieke Wichers<sup>k</sup>, Marc De Hert<sup>a,b,l,m</sup>, Davy Vancampfort<sup>b,n,1</sup>, Ruud van Winkel<sup>a,b,l,1,\*</sup>

<sup>a</sup> KU Leuven, Department of Neurosciences, Center for Clinical Psychiatry, Leuven, Belgium

<sup>b</sup> University Psychiatric Center KU Leuven, Leuven-Kortenberg, Belgium

<sup>c</sup> Department of Psychiatry and Neuropsychology, School of Mental Health and Neuroscience (MHeNS), Maastricht University, Maastricht, the Netherlands

<sup>d</sup> University Psychiatric Centre Sint-Kamillus, Bierbeek, Belgium

<sup>e</sup> Centre of Human Genetics, University Hospital Leuven, KU Leuven, Leuven, Belgium

<sup>f</sup> Department of Obstetrics and Gynecology, Ghent University Hospital, Ghent University, Ghent, Belgium

<sup>g</sup> Department of Neurology, Ghent University Hospital, Ghent University, Ghent, Belgium

<sup>h</sup> Faculty of Psychology, Open University of the Netherlands, Heerlen, Netherlands

<sup>i</sup> Department of Psychosis Studies, Institute of Psychiatry, King's Health Partners, King's College London, London, UK

<sup>j</sup> Department Psychiatry, Brain Center Rudolf Magnus, Utrecht University Medical Centre, Utrecht, the Netherlands

<sup>k</sup> University of Groningen, University Medical Center Groningen, University Center Psychiatry (UCP) Interdisciplinary Center Psychopathology and Emotion Regulation (ICPE), Groningen, the Netherlands

<sup>l</sup> KU Leuven, Department of Neurosciences, Center for Public Health Psychiatry, Leuven, Belgium

<sup>m</sup> Antwerp Health Law and Ethics Chair – AHLEC University Antwerpen, Antwerp, Belgium

<sup>n</sup> KU Leuven Department of Rehabilitation Sciences, Leuven, Belgium

### ARTICLE INFO

#### Keywords:

Physical activity  
Self-esteem  
Belonging  
Experience sampling method  
Young adult

### ABSTRACT

Physical activity has positive effects on self-esteem and sense of belongingness and vice versa. The experience sampling method allows for a level of analysis of the within-subject temporal dynamics of these interactions. We hypothesized that physical activity would predict prospective increases of self-esteem and belongingness in the flow of daily life, and vice versa. Additionally, we hypothesized that belongingness would predict self-esteem at the beep level. The study included 781 individuals ( $17.4 \pm 3.5$  years; 59% female) who responded to 10 beeps daily for 6 days to items on physical activity, self-esteem and belongingness. Univariate and multivariate multilevel models were used to examine within-person prospective bidirectional associations. We found that physical activity predicted higher self-esteem and belongingness at  $t_0+1$ . Participants who had a stronger increase of self-esteem following an increase in physical activity also had a concurrent stronger increase in belongingness. In contrast, self-esteem had no effect on physical activity at the next beep. Belongingness predicted self-esteem. We conclude that the interactions between physical activity, self-esteem and belongingness are complex and fluctuating in daily life. This has important implications for current theories describing the mental health benefits of physical activity.

### 1. Introduction

Physical activity, and in particular its structured form exercise, has many mental health benefits, both in clinical populations with a mental

disorder (Ashdown-Franks et al., 2020) and non-clinical populations (Rebar et al., 2015). One way in which physical activity can impact mental health is through an individual's self-esteem, which is the degree to which individuals appraise and value themselves (Biddle et al., 2015).

\* Corresponding author. Kapucijnenvoer 33, bus 7001, Blok H, 3000, Leuven, Belgium.

E-mail address: [ruud.vanwinkel@kuleuven.be](mailto:ruud.vanwinkel@kuleuven.be) (R. van Winkel).

<sup>1</sup> shared senior authorship.

Self-esteem has been shown to be an important contributing factor towards mental health (Biddle & Asare, 2011; Mann et al., 2004).

Self-esteem is often thought of as hierarchically structured with multiple dimensions leading to global self-esteem (Shavelson et al., 1976). These dimensions are comprised of academic and non-academic dimensions of the self that can be conceptualized and evaluated. Non-academic dimensions include emotional, social and physical aspects. The physical self-dimension is further divided into the subdomains physical acceptance and physical competence in Sonstroem & Morgans Exercise and Self-Esteem Model which was later further developed (Fox & Corbin, 2016; Fox & Lindwall, 2014; Sonstroem et al., 2016; Sonstroem & Morgan, 1989). This model provides a useful framework to study the relationship between physical activity and self-esteem. In this model, positive changes in physical or mental health parameters associated with physical activity (e.g., increased fitness or improved affect) are hypothesized to lead to enhancements in the perception of self-efficacy (i.e., beliefs in personal capabilities). Increased self-efficacy is then hypothesized to lead to improved self-perceptions in various physical subdomains (e.g., relative to physical strength, physical condition, body attractiveness, sports competence) which in turn increase global physical self-esteem. The lower levels are more closely related to specific situations and contexts and more easily changeable than the more stable global levels.

A meta-analysis showed that participation in exercise indeed improves self-esteem (Cohens'  $d = 0,23$ ) depending on change in physical fitness (Spence et al., 2005). More recent meta-analyses found similar results in children and adolescents (Ahn & Fedewa, 2011; Ekland et al., 2005; Liu et al., 2015). This association has also been found in longitudinal studies as well where higher physical activity predicts increased self-esteem in adolescents and adults (Elavsky, 2010; Reddon et al., 2017; Schmalz et al., 2007; Wagnsson et al., 2014).

The above is also commonly referred to as the skills development hypothesis wherein physical activity leads to self-esteem (Sonstroem, 1998). However, the reverse may also be true, in that greater self-esteem may lead to more physical activity. This is called the self-enhancement hypothesis which focuses on the influence of self-esteem on the environment (Lindwall & Asçi, 2014). People often tend to do that which they deem to be good at. As such, people with high self-esteem and in particular physical self-esteem will perform physical activity more often. This way, they confirm their own self-perceptions and expectations. Several cross-sectional and longitudinal studies in adolescents and adults support this relationship (Carter, 2018; Crocker et al., 2006; Knowles et al., 2009; McAuley et al., 2005; Raustorp & Lindwall, 2015; Sonstroem et al., 1992).

The basic assumption of the bidirectional association between physical activity and self-esteem is that self-esteem is an intra-individual psychological (cognitive-evaluative) process. However, individuals form social relationships and these relationships affect intrapsychic processes. The sociometer theory emphasizes that self-esteem is also an expression of a relational value and thus inter-individual. Self-esteem becomes a subjective gauge of the degree to which people perceive they are relationally valued and socially accepted by others. As such, it is not something individuals strive for *per se* (Leary, 2005; Leary & Baumeister, 2000). Self-esteem as a sociometer is only relevant if it is of crucial importance to be accepted in peer groups. The sociometer theory is thus embedded in a broader basic human need to belong (belongingness) (Baumeister & Leary, 1995).

Evidence for the relationship between physical activity, self-esteem and belongingness is beginning to emerge. In a systematic review examining physical activity and loneliness, Pels and Kleinert (2016) found a bidirectional inverse relationship. The beneficial effect of physical activity on loneliness is dependent on the quality of the relationships present during physical activity (Pels & Kleinert, 2016). In lonely rejected adults, framing physical activity as a way to increase social connectivity helps to increase self-regulatory efficacy or a person's belief in their ability to accomplish specific physical activity goals

(Dowd et al., 2014). In women taking part in a fitness program, greater social belonging was associated with more physical activity (Cuprika et al., 2015). The relation holds on a community level as well, i.e. community social cohesion is associated with increased physical activity (Yip et al., 2016). Not all studies have found evidence in support of the sociometer theory, however. In an elderly population of retirees, for example, physical activity alone or with others was not associated with increased sense of belonging (Bailey & McLaren, 2005).

The sociometer theory posits that belongingness (and thus self-esteem) can change depending on the context (Leary, 2005). This fits with the observation that self-esteem is not always a stable construct (Marsh & Yeung, 1998), but can be rather reactive and changing throughout the day and across days and can be influenced from moment to moment (Kernis, 2005). Especially in adolescence, self-esteem is still unstable and contingent on self-relevant events (Erol & Orth, 2011; Meier et al., 2011). This is important since momentary changes in self-esteem have been found to induce paranoid symptoms and anxiety both in people with mental health disorders and the general population (Thewissen et al., 2007, 2008, 2011).

To date, research has primarily focused on correlational studies to investigate the relationship between physical activity and self-esteem, limiting causal inference. Many studies also relied on self-report measures determining mean levels of physical activity or self-esteem over days or weeks, implicating recall bias (Althubaiti, 2016). The longitudinal studies previously mentioned (Carter, 2018; Crocker et al., 2006; Raustorp & Lindwall, 2015; Reddon et al., 2017; Schmalz et al., 2007; Wagnsson et al., 2014) have focused on changes over extended periods of time such as months to years, neglecting the possible dynamic day-to-day interplay of physical activity and psychological aspects of well-being. Therefore, there is a dire need for research focusing on the micro-level of daily fluctuations and interactions between physical activity, self-esteem and belongingness in the flow of daily life, from moment to moment. We aimed to address these issues in this study by employing an ecological momentary assessment methodology, also called experience sampling method (ESM) (Myin-Germeys et al., 2009). Using this method, it is possible to assess (self-reported) physical activity, self-esteem and belongingness multiple times per day and for multiple consecutive days. This reduces recall bias and leads to a more ecologically valid measurement (Dunton, 2017; Stone & Shiffman, 2002). Because of the multilevel nature of data acquired this way, this type of analysis also allows for the examination of time-varying within-person dynamics in the constructs under investigation. As such, we can see how physical activity, self-esteem or belongingness can change from moment to moment within participants. In short, we get a much more fine-grained image of fluctuations in these variables in the daily lives of people. We hypothesize that: (A) physical activity at  $t_0$  will increase both self-esteem and belongingness the following moment ( $t_0+1$ ), (B) the relationship will be bidirectional with higher self-esteem and belongingness at  $t_0$  also predicting higher consecutive physical activity at  $t_0+1$ . Finally (C), according to sociometer theory, belongingness at  $t_0$  will predict moment-to-moment self-esteem at  $t_0$ .

## 2. Materials and methods

### 2.1. Participants

Participants were sampled from the East Flanders Prospective Twin Survey (EFPTS) (Derom et al., 2002, 2019). The EFPTS is a prospective, population-based registry of multiple births in the province of East Flanders, Belgium, which has been recording data on twins since 1964. The TwinssCan project (Pries et al., 2019) collected data from the EFPTS on adolescents and young adults between 15 and 35 years between April 2010 and April 2014. It included 840 participants: 292 monozygotic twins, 486 dizygotic twins, 18 triplets and 43 siblings and 1 participant for whom no data on twin or sibling status was present. Furthermore, data from 363 parents were assessed, but these were not used in the

present study. The project was approved by the Local Ethical Committee UZ/KU Leuven (Commissie Medische Ethiek van de Universitaire ziekenhuizen KU Leuven, Nr. B32220107766) and all participants gave their written informed consent. Furthermore, the study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki. If the participant was younger than 18 years, parents also signed informed consent. Candidate-participants were ineligible for participation if they had a pervasive mental disorder as reported by caregivers.

## 2.2. ESM method

ESM is a structured diary technique to assess participants in their daily living environment, which has been ecologically validated for studying moment-to-moment variation in affect and subtle psychotic experiences (Myin-Germeys et al., 2009; Simons et al., 2007). Participants received an electronic medical Personal Digital Assistant, especially developed for this purpose. This custom-made PDA has been patented and is called the 'Psy-mate'. The Psy-mate is programmed to emit a signal ("beep") at an unpredictable moment in each of ten 90-min time blocks between 7:30 and 22:30, on six consecutive days. After each beep, participants are asked to stop their activity and to answer questions regarding their mental state, context and physical activity in the Psy-mate (Derom et al., 2019). To ensure validity of the questions, items were selected by an expert panel based on previous research (Thewissen et al., 2007; Wichers et al., 2012). Participants are instructed to complete their reports immediately after the beep, thus minimizing memory distortion. In order to assure reliability and validity the Psy-mate records the time at which participants completed the assessment. Reports need to be completed within 15 min of the beep, otherwise the data for this time point were considered missing (Devries & Delespaul, 1989). Although many previous ESM studies have set a minimum compliance threshold for the number of valid beeps, recent evidence demonstrated that this might lead to biased estimates and as such is not best practice (Jacobson, 2020). Therefore, all available data was used in the current study.

The ESM procedure was explained to the participants during an initial briefing session and a practice trial was performed to confirm that participants were able to understand the response format in order to further enhance validity.

## 2.3. Measures

### 2.3.1. Physical activity

Measures of physical activity were collected at each beep. ESM physical activity was assessed with a single item asking participants how physically active they had been since the last beep, rated on a 7-point Likert scale. This method has been used in previous research (Wichers et al., 2012). During the ESM briefing, participants were instructed how to score their level of physical activity. To this end, they were given an indication of the level of activity that corresponded to the score on the 7-point Likert scale. Anchor points were provided as examples, as follows: a score of 1 corresponds to the level of physical activity of "resting"; 2 corresponds to "sitting"; 3 to "walking"; 4 to "household chores such as vacuum cleaning"; 5 to "biking"; 6 to "playing tennis"; and 7 to "running". These anchor points were also provided in the ESM self-assessment forms participants completed at each beep.

### 2.3.2. Self-esteem

Measures of self-esteem were collected at each beep. Self-esteem was assessed with four items on a 7-point Likert scale, two positively worded aspects of self-esteem ("I like myself", "I am satisfied with myself") and two negatively worded aspects of self-esteem ("I doubt myself", "I am ashamed of myself"). Anchors were provided on the Likert scale at each beep: 1 being "Not at all", 4 being "Moderate" and 7 being "Very Much". These items were drawn from previous research, where both a one factor

solution (Thewissen et al., 2011) or a two factor solution (Udachina et al., 2009) was found. However, research examining measurement of self-esteem found evidence for a unidimensional self-esteem concept with a division in positive and negative self-esteem being method artefacts from the phrasing of the items (Corwyn, 2000; DiStefano & Motl, 2009; Horan et al., 2003; Marsh et al., 2010; McKay et al., 2014; Michaelides et al., 2016; Tomás & Oliver, 1999). It is therefore advised to only retain the positively worded items as a measure of self-esteem since this measures the concept more accurately (Lindwall et al., 2012; Podsakoff et al., 2003; Schriesheim & Hill, 1981). Thus, a variable was constructed measuring self-esteem by taking the mean of the two positively worded items "I like myself" and "I am satisfied with myself".

### 2.3.3. Belongingness

Measure of sense of belonging was collected whenever a participant reported that they were in the company of other people. This was done to make the sense of belonging concrete in each situation. Sense of belonging was assessed with an item on a 7-point Likert scale ("I belong in this company"), semi-anchored with 1 being "Not at all", 4 being "Moderate" and 7 being "Very Much".

## 2.4. Statistical analysis

Statistical analysis was performed in R (R Core Team, 2020). As described above, rows with beep delay >15 min, and day number >6 were considered invalid observations and omitted. All analyses were three level multilevel models. Level 1 was the beep level, level 2 was the participant level, level 3 was the twin level. Level of significance was set at  $\alpha = 0.05$ . The package "nlme" in R was used to this end (Pinheiro et al., 2019, pp. 1–152). For missing data, we assumed data was Missing At Random and modeled this using the direct likelihood method for linear mixed effects models (Little & Rubin, 2020; Molenberghs & Kenward, 2007). A direct likelihood or likelihood-based ignorable analysis uses all available information, without the need either to delete nor to impute measurements or entire subjects. By using this method, appropriate adjustments are made to parameters at times when data are incomplete due to the within-subject (and within-twin) correlation. Given the large sample size of this study, the central limit theorem guarantees that relevant test statistics will be normally distributed and testing for normality is actually redundant. We visually inspected linearity and introduced, where relevant, the necessary polynomials of the predictors of interest to the model. For each model intraclass correlation at the twin-level, subject-level and subject nested within twin-level were calculated and the variance explained by the model or  $f^2$  was calculated for each model (Lorah, 2018).

### 2.4.1. Effect of physical activity on self-esteem and belongingness

A linear multivariate multilevel model was fitted with self-esteem and belongingness at  $t_0$  as outcome and physical activity as predictor (MacCallum et al., 1997). The assessment of physical activity concerns the period between the last beep up to the current beep. As such, it precedes the assessment of psychological constructs such as self-esteem and belongingness, which are assessed at the beep moment. However, it is possible that participants are still performing physical activity at the time of the beep. In this specific case, the association between physical activity and self-esteem/belongingness would be cross-sectional rather than prospective. Therefore, we also conducted a sensitivity analysis with physical activity as measured at the previous beep, i.e. between beep  $t_{0-2}$  and  $t_{0-1}$ . This sensitivity analysis has the advantage of being a prospective analysis with certainty, but the disadvantage that the time between physical activity and the measurement of self-esteem and belongingness is quite long (2–3 h), possibly too long to properly examine the underlying dynamics. Therefore, we consider the analysis using physical activity measured in the period between the last beep up to the current beep as our primary analysis.

Physical activity was person mean centered. By doing so, the variable

is divided into the person's mean to examine between-subject effects and the deviation from the person's mean to examine within-subject effects (Shiffman et al., 2008). Since our hypotheses concern the within-subject effects, we only report these in the results. In addition, we included the lagged variable (lagged self-esteem and belongingness) at  $t_0-1$  as an autoregressive predictor. Gender and age were included as a priori defined confounders. We modeled random intercepts at the twin level and random intercepts and random slopes at the participant level for within subject variables.

#### 2.4.2. Effect of self-esteem and belongingness on physical activity

To examine the temporal effect of self-esteem and belongingness at  $t_0$  on physical activity, we created a lead variable at  $t_0+1$  for physical activity. A linear univariate multilevel model was fitted with lead physical activity as outcome variable and self-esteem and belongingness as predictors. All predictors were again person mean centered and we report the within-subject effects. Physical activity at  $t_0$  was taken as a separate autoregressive predictor. Sex and age were included as a priori defined confounders. We modeled random intercepts at the twin level and random intercepts and random slopes at the participant level for within-subject variables.

#### 2.4.3. Effect of belongingness on self-esteem

Sociometer theory predicts that self-esteem and belongingness are at all times related. In order to examine the relationship between self-esteem and belongingness we fitted a univariate linear multilevel model with self-esteem as outcome and belongingness as predictor. This was our primary analysis. Belongingness was person mean centered and we report the within-subject effects. Age and gender were included as a priori defined confounders. Self-esteem at  $t_0-1$  were added to the model as autoregressive predictors. We modeled random intercepts at the twin level, and random intercepts and random slopes at the participant level for within-subject variables. To evaluate the effect of belongingness on subsequent self-esteem, we conducted a sensitivity analysis where we used self-esteem at  $t_0+1$  as outcome variable, again with random intercepts and fixed slopes at the participant level for within-subject variables.

### 3. Results

#### 3.1. Sample

840 participants took part in the study with a total of 33,931 observations resulting in an overall completion rate of 67%. The participant identity from one participant was invalid, 11 participants had invalid day numbers, 1 participant had invalid beep numbers leaving 827 participants with 33,301 observations. Observations where beep-response interval was more than 15 min and day number was more than 6 were omitted leaving 781 participants (92%) with 25,487 observations resulting in a completion rate of 55%. 320 participants were male, 461 were female. Mean age was 17.4 (SD = 3.56). The mean self-esteem was 5.1 (SD = 1.12, missing data <0.001%), mean belonging 6.0 (SD = 1.15, missing data = 0.004%) and mean physical activity 2.5 (SD = 2.02, missing data = 0.005%).

#### 3.2. The effect of physical activity at $t_0-1$ on subsequent self-esteem and belonging at $t_0$

Physical activity had a small, but significant positive effect on subsequent self-esteem (beta = 0.01, SE = 0.004,  $p = 0.024$ ). Physical activity had a small negative effect on subsequent belongingness (beta = -0.03, SE = 0.007,  $p < 0.0001$ ). Results are shown in Table 1 and graphically depicted in Fig. 1. The correlation between the participant-specific slopes of physical activity on self-esteem and the participant-specific slopes of physical activity on belongingness was 0.86 indicating that participants who show a stronger correlation between

**Table 1**

-Within-Subject Effect of Physical Activity at  $t_0$  on Positive & Negative Self-Esteem and Belongingness at  $t_0+1$ .

Fixed effects	Coefficient	SE	t-Value (DF)	p-Value
PA on SE	0.01	0.004	2.26 (27,419)	0.024*
PA on B	-0.03	0.007	-4.10 (27,419)	<0.0001*

B = Belongingness, DF = degrees of freedom, SE = Self-Esteem, PA = physical activity, SE = standard error \*Significant when  $p < 0.05$ .

physical activity and self-esteem also show a stronger correlation between physical activity and belongingness (see Fig. 2). Intraclass correlations for twin, subject in subject in twin were respectively 0.15, 0.34 and 0.48.  $F^2$  for the full model was 0.28 with self-esteem as outcome and 0.35 with belongingness as outcome. In the sensitivity analysis using physical activity assessed between  $t_0-2$  and  $t_0-1$ , no significant within-subject effects were observed.

#### 3.3. The effect of self-esteem and belonging at $t_0$ on subsequent physical activity at $t_0+1$

Both self-esteem and belongingness did not increase subsequent physical activity (see Table 2). The correlation between participant-specific slopes of self-esteem on physical activity and belongingness on physical activity was -0.25 indicating a moderate negative correlation between the slope for self-esteem on subsequent physical activity and belongingness on subsequent physical activity. Intraclass correlations for twin, subject in subject in twin were respectively 0.07, 0.16 and 0.23.  $F^2$  for the full model was 0.12.

#### 3.4. The relationship between self-esteem and belonging at $t_0$

Fixed effects results are depicted in Fig. 1. Higher belongingness was associated with increased self-esteem (beta = 0.11, SE = 0.01,  $p < 0.0001$ ). Intraclass correlations for twin, subject in subject in twin were respectively 0.17, 0.41 and 0.58.  $F^2$  for the full model was 0.58.

Our sensitivity analysis, using self-esteem at  $t_0+1$  as outcome variable, revealed an effect of belongingness on self-esteem (beta = 0.02, SE = 0.007,  $p = 0.007$ ).

### 4. Discussion

#### 4.1. Findings

To the best of our knowledge, the current study is the first to analyze the relationships between physical activity, self-esteem and belongingness at the within-person level of daily fluctuations. Our study demonstrates that physical activity positively predicts subsequent self-esteem and negatively predicts subsequent belonging. Our results demonstrated notable individual differences in how people react to physical activity. People who experience a stronger increase in positive self-esteem following physical activity, have a more neutral or even a positive effect of physical activity on belongingness and vice versa. When looking at the reversed relation, self-esteem and belongingness have no effect on subsequent physical activity, although significance was at trend level. Finally, higher belongingness was associated with higher self-esteem.

#### 4.2. Physical activity and prospective self-esteem

The positive effect of physical activity on self-esteem is in line with previous evidence (Ekeland et al., 2005; Joseph et al., 2014; Spence et al., 2005) and with Sonstroem & Morgan's exercise and self-esteem model (Sonstroem & Morgan, 1989). The present study demonstrates that these interactions fluctuate over the course of the day, from moment to moment. These effects are small, but significant. It might be hypothesized that these small effects, if systematic and cumulative, add

Within-Subject

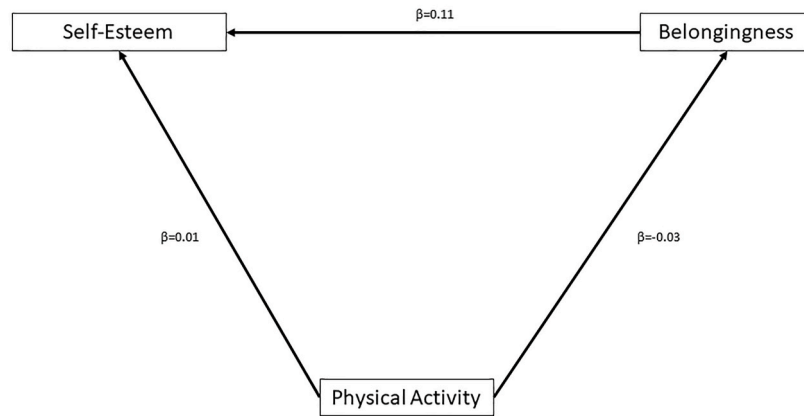


Fig. 1. Within-subject results for the relations between Physical Activity, Self-Esteem and Belongingness.

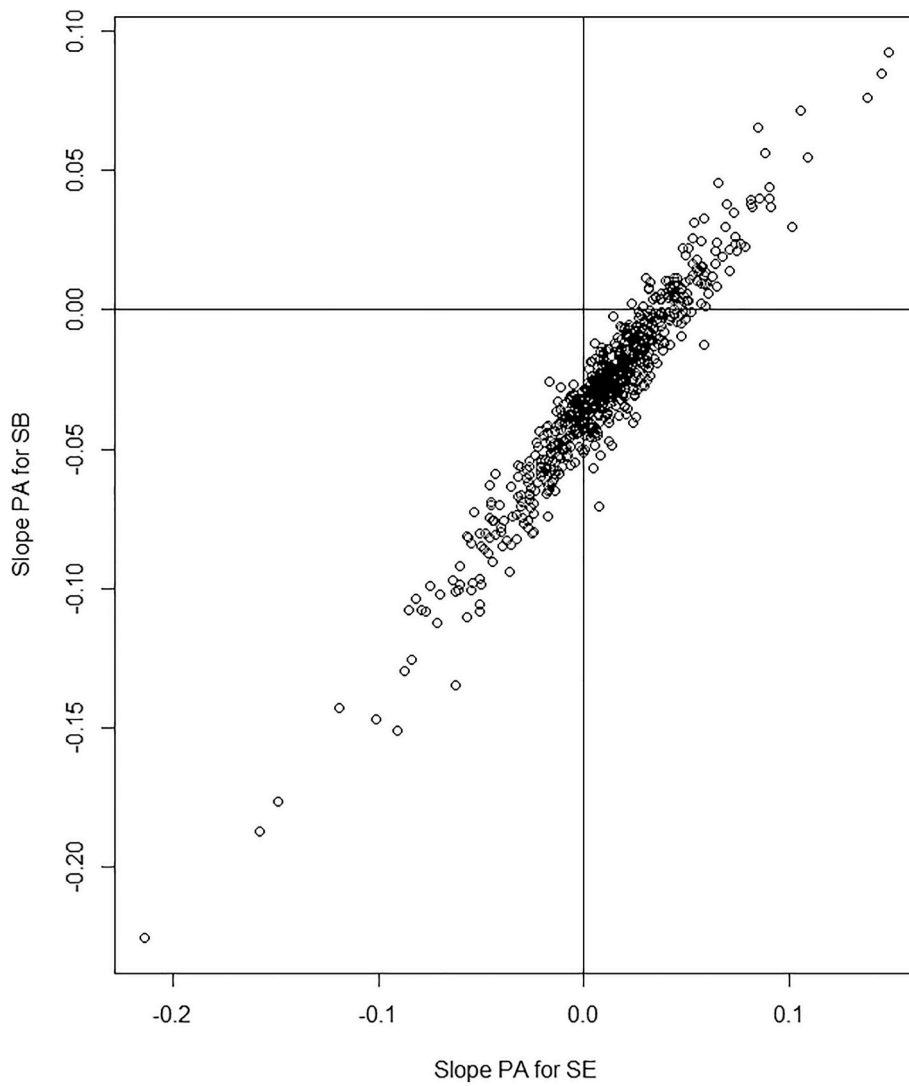


Fig. 2. Correlation slopes of physical activity with self-esteem and belongingness. SE = self-esteem, PA = physical activity, SB = social belongingness. The correlation is 0.86.

**Table 2**  
Effect of Self-Esteem and Belongingness at  $t_0$  on Physical Activity at  $t_0+1$ .

Fixed effects	Coefficient	SE	t-Value (DF)	p-Value
SE on PA	0.04	0.02	1.91 (14,258)	0.056
B on PA	-0.03	0.02	-1.70 (14,258)	0.09

B = Belongingness, DF = degrees of freedom, SE = Self-Esteem, PA = physical activity, SE = standard error \*Significant when  $p < 0.05$ .

up over time possibly resulting in larger effects. For example, over a time period of four years, physical activity was associated with higher self-esteem in a longitudinal study (Reddon et al., 2017). Overall, our model explained 28% of the variance for predicting self-esteem at the next moment, which is a moderate effect. Our sensitivity analysis revealed that the effects of physical activity on self-esteem are probably short lived since we did not find within-person effects of physical activity two to three hours before the current beep, stressing the dynamic and fluctuating nature of these associations.

Our data also demonstrate that the effect of physical activity on self-esteem varies per person: some people tend to react more positively to physical activity, while others show little reactivity or even a negative effect of physical activity on self-esteem (see Fig. 2). This is an important finding, as it demonstrates that physical activity is not a 'one size fits all' intervention to improve self-esteem. It might give a boost to self-esteem for one person, but have a negative impact on self-esteem for another person. Recommending physical activity should thus be tailored towards the individual and his or her needs, expectations and motivation (Kipp & Weiss, 2013; Rodriguez-Ayllon et al., 2019; Teychenne et al., 2020). Future research into the effects of physical activity on well-being should take this into account.

A possible reason why the effect of physical activity on self-esteem is rather small may lie in the difference between exercise and physical activity. While exercise is structured physical activity, the physical activity in our study also included non-structured ways of being physically active such as commuting, walking from point A to point B, or doing household chores (Caspersen et al., 1985). The relationship between this kind of physical activity and self-esteem may not be as tangible as or may be different than the relationship between exercise and self-esteem. This may be related to both the nature of the activity itself (pleasant or unpleasant, e.g. sports versus vacuum cleaning, whether it's something you chose to do or not, your motivation to do the activity) or the talent or joy that individual participants themselves derive from these activities.

#### 4.3. Self-esteem and prospective physical activity

Our findings concerning the effect of self-esteem on physical activity are contrary to the self-enhancement hypothesis. The effect does not reach statistical significance, but appears to be at trend level. This might be in line with previous studies, which showed that the effect of self-esteem on physical activity is rather small and that social support is a far more potent predictor for physical activity (Jekauc et al., 2019).

#### 4.4. Effect of physical activity on belongingness

In line with other studies (Whiteman-Sandland et al., 2018), we found a relationship between physical activity and belongingness. However, our data show that physical activity leads on average to a small decrease in subsequent belongingness. So, although some people experience a beneficial effect of physical activity on belongingness, most experience a slight increase in self-esteem at the cost of a reduction in belongingness (see Fig. 2). It should also be noted that we did not find evidence that belongingness increases subsequent physical activity. It is likely that improving general belongingness in day-to-day activities will not lead to more physical activity.

A possible explanation might lie in the way belongingness was

measured or operationalized in other studies. These studies mainly measured belongingness through a proxy such as social support or social support specific for physical activity (Jekauc et al., 2019; Lindsay Smith et al., 2017; Mendonça et al., 2014), social identity (Bratt, 2015; Stevens et al., 2017) or loneliness (Pels & Kleinert, 2016). On the other hand, we did not measure belongingness specifically related to physical activity or exercise participation, but on a more general level. It is possible that physical activity does increase belongingness, but only belongingness within the group that supports the individual in doing physical activity or with whom the individual engages in physical activity. Another possible explanation might lie at the level of analysis: evidence for relationships at the between-subject level do not always remain the same at the within-subject level. For example, empirical evidence has shown that an individual is more likely to experience a heart attack while exercising (i.e., the within-subject effect), but at the same time people who exercise more tend to have a lower risk of heart attack (i.e., the between-subject effect) (Mittleman et al., 1993). This requires further research.

#### 4.5. Effect of belongingness on self-esteem

Our finding that belongingness predicts self-esteem at every moment is in line with the sociometer theory (Leary & Baumeister, 2000). Baumeister & Leary hypothesized that a sociometer system should be functional on both state and trait self-esteem (Leary & Baumeister, 2000) and that state self-esteem is paramount for the functioning of the sociometer (Leary et al., 1995). By examining within-person effects, we were able to confirm this hypothesis. Our model also explained 58% of the variance in self-esteem, which is a large effect. This adds further credibility to the central assumptions of sociometer theory. Additionally, our sensitivity analysis showed that these effects partially translate to a subsequent moment since belongingness at  $t_0$  had a much-reduced effect on self-esteem at  $t_0+1$ . This is in accordance with the reactive nature of state self-esteem and belongingness. A study by Denissen et al. (Denissen et al., 2008) also examined the effect of daily fluctuations in social inclusion on self-esteem and found that daily perceptions of interaction quality were consistently linked to self-esteem. When aggregating the diary data for inter-individual analyses, they replicated the intra-individual result. Our study demonstrates an even finer grained look into the dynamics of within-day fluctuations in self-esteem and belongingness adding another layer of analysis. Although we examined this relationship over the course of days, evidence also demonstrates similar effects over the course of weeks and years (Denissen et al., 2008; Mayer & Bouffard, 2019; Murray et al., 2003). The fact that results at different levels of analysis converge should be seen as strong evidence in support of the sociometer theory. Efforts to increase people's momentary belongingness will thus lead to increased self-esteem and well-being. This can be leveraged in prevention or therapeutic programs to enhance efficacy. Indeed, a program focused on improving connectedness in adolescents exposed to bullying suggested increased self-esteem (King et al., 2018). Sense of belonging can thus be a reliable target for intervention in future studies. Furthermore, thwarted belongingness has been implicated in a pathway leading to suicide both in veterans and adolescents (Czyz et al., 2015; Wastler et al., 2020). More research into belongingness should thus be welcomed.

#### 4.6. Limitations

Although the current study has a number of strengths, it also has several limitations. First and foremost, due to the structure of the ESM-questions we did not have any information on duration of physical activity and a relatively crude view on the intensity of physical activity. As such, no conclusions can be drawn regarding the type and duration of physical activity necessary to promote its effects on self-esteem. Future research could also use accelerometers to have a more objective measure of physical activity. Second, our sample consisted mainly of adolescents

and young adults restricting the generalizability of these findings to the general population. However, studying these interactions can also be considered a strength, since in this age range these processes are still highly dynamic, allowing for a compelling view of the interrelations between physical activity, self-esteem and belongingness.

## 5. Conclusion

The moment-to-moment interactions between physical activity on the one hand, and important psychological concepts, such as sense of belonging and self-esteem on the other, are complex and fluctuating. Within-subject effects do not necessarily replicate between-subject effects and it is important to interpret the results at the right level of analysis. Our findings have important implications for current theories linking physical activity and psychological well-being. We find evidence for the Sonstroem & Morgan or skills development model at the level of moment-to-moment within-subject level. However, our data also show that there is a large variability in how people react to increases in physical activity and as such physical activity interventions should take this into account. Moreover, rather than only relying on crude associations over extended periods of time, studies examining the effects of physical activity on psychological outcomes should take the dynamic nature of these interactions into account. We did not find evidence for the reverse relation, namely the self-enhancement theory. Our data support the central tenets of sociometer theory showing that moment-to-moment belongingness is related to self-esteem and subsequent self-esteem. This puts sense of belonging on the stage as an important point of possible intervention to modulate self-esteem and enhance wellbeing.

## List of abbreviations

No abbreviations used.

## Ethics approval and consent to participate

The project was approved by the Local Ethical Committee UZ/KU Leuven and all participants gave their written informed consent. If the subject was younger than 18 years, parents also signed informed consent.

## Funding

The research leading to these results has received funding from the European Community's Seventh Framework Program under grant agreement No. HEALTH-F2- 2009–241,909 (Project EU-GEI). This work was also supported by a FWO Senior Clinical Investigator (1803616 N) grant to RVW, and by the Funds Julie Renson, Queen Fabiola and King Baudoin Foundation.

## Authors' contributions

RvW, JD, MDH, CD, NJ, CM-L, JvO, ET, BPR and MW designed the study, wrote the Protocol and conducted the research. VM, DV and RvW managed the literature searches and analyses. VM and KV undertook the statistical analysis. VM wrote the first draft of the manuscript, which was critically revised by DV and RVW. All authors contributed to and have approved the final manuscript.

## Consent for publication

Not applicable.

## Availability of data, materials and code

The dataset and code used for the current study are available in the

Open Science Framework repository, [https://osf.io/dv5kf/?view\\_only=d8155933a4eb4b9ea79ddcf83c6fd0d2](https://osf.io/dv5kf/?view_only=d8155933a4eb4b9ea79ddcf83c6fd0d2).

## Declarations competing interests

The authors declare that they have no competing interests.

## Acknowledgements

We thank all twins for their cooperation as well as the support by Twins, a non-profit association for scientific research in multiple births (Belgium) to the East Flanders Prospective Twin Survey.

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