Journal Pre-proof

Leave the Screen: The Influence of Everyday Behaviors on Self-reported Interoception

A Wallman-Jones, C Nigg, Benzing, M Schmidt

PII: S0301-0511(23)00117-5

DOI: https://doi.org/10.1016/j.biopsycho.2023.108600

Reference: BIOPSY108600

To appear in: *Biological Psychology*

Received date: 28 November 2022
Revised date: 2 June 2023
Accepted date: 3 June 2023

Please cite this article as: A Wallman-Jones, C Nigg, Benzing and M Schmidt, Leave the Screen: The Influence of Everyday Behaviors on Self-reported Interoception, *Biological Psychology,* (2023) doi:https://doi.org/10.1016/j.biopsycho.2023.108600

Leave the screen: the influence of everyday behaviors on self-reported interoception.

Wallman-Jones. A[1,2*]., Nigg. C[1]., Benzing, V[1]., Schmidt. M[1].

[1]Institute of Sport Science, University of Bern, Bern, Switzerland.

[2]Department of Neurology, University of California, San Francisco, CA, USA.

*Corresponding author: Please address all comments and questions to Amie Wallman-Jones at amie.wallman-jones@unibe.ch. 145 Bremgartenstrasse, 3012, Bern, Switzerland.

Abstract

The influence of physical activity on interoception is apparent, however little is known about within-person variability following physical activity and sedentary behavior in daily life. To test this, 70 healthy adults (M_{age} 21.67±2.50) wore thigh-mounted accelerometers for 7-days, with self-reported interoception recorded on movement-triggered smartphones. Participants additionally reported the predominant activity type performed across the last 15 minutes. Investigating this timeframe, multi-level analyses revealed that each one-unit increase in physical activity was associated with an increase in self-reported interoception (B = 0.0025, p = .013), whereas contrastingly, each one-minute increase in sedentary behavior was associated with a decrease (B = -0.06. p = .009). Investigating the influence of different activity types in comparison to screen time behavior, both partaking in exercise (B = 4.48, p <.001) and daily-life physical activity (B = 1.21, p <.001) were associated with an increase in self-reported interoception. Regarding other behavior categories, non-screen time behavior both with (B = 1.13, p <.001) and without (B = 0.67, p = .004) social interaction were also associated with an increase in self-reported interoception compared to screen-time behavior. Extending from previous laboratory-based studies, these findings indicate that physical activity influences interoceptive processes in real-life, further supplemented by the novel and contrasting findings regarding sedentary behavior. Furthermore, associations with activity type reveal important mechanistic information, highlighting the importance of reducing screen-time behavior to preserve and support interoceptive perceptions. Findings can be used to inform health

recommendations for reducing screen-time behavior and guiding evidence-based physical activity interventions to promote interoceptive processes.

Keywords: *exercise, body-awareness, embodiment, movement*

1. Introduction

A healthy and accurate perception of the body is considered important for self-regulation (Quigley et al., 2021), where historically, the importance of somatic cues has been a core assumption of peripheral emotion theories (Cannon, 1927). Accordingly, research into interoception, the sense of the physiological condition of the body, has gained increased attention in recent years (Khalsa et al., 2018). This has led to significant findings regarding between-subject variability in interoceptive abilities, and as such how these differences may be predictive of self-regulatory strengths and weaknesses (Tsakiris & Critchley, 2016). Contrastingly, within-subject variability is under-researched, despite it being well accepted that interoception can be considered a state, as well as a trait, variable (Wittkamp et al., 2018). While this was supported by a recent pilot study reporting daily variability across interoceptive dimensions (Höller et al., 2021), it remains unclear as to how different everyday behaviors influence these patterns in a real-world setting.

Whilst interoceptive processes predominantly serve to sustain allostasis, higher-level inferences regarding these bodily changes are reported to have social, emotional, and behavioral implications (Tsakiris & Critchley, 2016). Respectively, empirical evidence supports its role in operating self-other distinctions in social interactions (Palmer & Tsakiris, 2018), influencing the strength of our emotional experience (Critchley & Garfinkel, 2017; Pollatos & Schandry, 2008; Terasawa et al., 2013), and regulating physical exertion (Georgiou et al., 2015; Herbert et al., 2007). Identifying individual differences in ability has therefore been integral in understanding the clinical implications of aberrant interoception.

Reflecting its hierarchical structure, recent conceptualizations of interoception are multi-dimensional (Suksasilp & Garfinkel, 2022), advancing on previous, oversimplified frameworks (Garfinkel, Manassei, et al., 2016). They comprise of various levels of processing, spanning from the periphery to the central nervous system. These include more subjective dimensions, such as *self-reported interoception* (previously referred to as sensibility) – "The ability to reflect upon ones' autobiographical experiences of interoceptive states, make judgements about their outcomes, and describe them through verbal or motor responses" (Khalsa et al., 2018), as well as more objectifiable dimensions, such as *interoceptive accuracy* – the accurate and precise monitoring of physiological signals, commonly indexed through performance in behavioral tests (Garfinkel, Tiley, et al., 2016). Unequivocally, most research has focused on more objectifiable dimensions, providing the basis for metacognitive evaluations to evolve (Garfinkel et al., 2015). It is becoming increasingly accepted, however, that self-reported interoception is also important for self-regulation (Gabriele et al., 2022; Nord & Garfinkel, 2022), whereby a heightened yet healthy subjective perception of the body has been deemed adaptive, in contrast to the maladaptive anxiety-induced hypervigilance observed in somatization (Trevisan et al., 2021). Here it has been argued that self-reported interoception may even prove to be a better predictor of clinical status than behavioral or neural-based measures for many clinical manifestations (Suksasilp & Garfinkel, 2022).

Regarding physical self-regulation, self-reported interoception is notably relevant during physical activity, where subjective perceptions of physical fatigue have long been used as a guide of exertion (Borg, 1982). In this way, the conscious observation and evaluation of interoceptive cues can allow for a more efficient self-monitoring of bodily resources to pace accordingly (McMorris et al., 2018), supported by an improved regulation of exertion recorded when using associative attention strategies (Razon et al., 2010, 2014). Interestingly, physical activity, defined as any bodily movement produced by skeletal muscles that results in energy expenditure (Caspersen et al., 1985), has been proposed to simultaneously benefit interoceptive processing across multiple levels, acting as a form of interoceptive exposure to improve brain-body communication (Wallman-Jones et al., 2021; Zarza et al., 2019). Acutely, short bouts of physical activity influence both interoceptive accuracy and self-reported interoception (Antony et al., 1995; Jones & Hollandsworth, 1981; Montgomery et al., 1984; Wallman-Jones et al., 2022), where changes are thought to arise based on two key mechanisms: an increased attentional capacity to bodily signals, as well as an increased salience of the signals themselves (Georgiou et al., 2015; Wallman-Jones et al., 2021). Accumulated adaptations through repeated exposure are then proposed to promote habituation through altering anticipatory representations of interoceptive sensations (Garfinkel, Manassei, et al., 2016). This is supported by previous research, where interventions containing a physical activity component have been found successful in influencing interoceptive processing at both the self-report and behavioral level (Mölbert et al., 2016; Quadt et al., 2021).

Juxtaposed to physical activity-related adaptations, sedentary behavior is proposed to contribute to an "untrained" interoceptive pathway (Wallman-Jones et al., 2021). In this way, the absence of exercise-induced changes constrains sympathetic stimulation, potentially limiting the capacity for subsequent higher-level adaptations. Overtime, this reduced brain-body communication could result in a mismatch between the actual and perceived state of the body, reflected by inaccurate and unhealthy beliefs. While not a direct measure of physical inactivity, implicit support comes from negative correlations with body mass index (BMI), where overweight populations appear to present difficulties in accurately perceiving their internal physiology (Robinson et al., 2021). Furthermore, sedentary individuals have been found to display differences in their neurophysiological pre-conscious processing of heartbeats compared to trained individuals, demonstrated by a reduced heartbeat evoked potential (HEP) (Perakakis et al., 2017). These findings emulate those of Paulus and colleagues (2015), whereby elite athletes showed attenuated neural processing in the anterior insula cortex to aversive interoceptive stimulation compared to non-athletes, an area implicated in the regulation of attention towards interoceptive cues (Wang et al., 2019). Here it was hypothesized that experience in physical activity translates to a better and more efficient adaptation to physiological perturbations, i.e., more efficient interoceptive processing (Paulus et al., 2012). Together, these findings point to the deleterious effects of sedentary behavior, contrasted to the notable benefits observed from physical activity. It remains unclear, however, as to what characteristics of sedentary behavior result in these responses, and whether they can be generalized to all activity types.

It is becoming increasingly evident that the type of sedentary behavior is important to consider (Kanning et al., 2021), where reading a book or partaking in mindfulness activities are likely to have different health implications than engaging in screen-based activities. Extending this idea to interoception, theories propose that excessive screen time interferes with our embodied experience within the world (Puk, 2021). Whilst evidence is scarce, initial findings indicate that excessive screen-time is linked to reduced resting state functional connectivity in the insula cortex, a key region of the interoceptive domain thought to regulate interoceptive attention (Paik et al., 2019). This was further supported in a more recent study regarding problematic smartphone use, whereby altered functional connectivity in the cingulate cortex was proposed to draw attention to external stimuli and away from interoceptive cues (Kwon et al., 2022). This growing body of literature supports the importance of sedentary behavior characteristics in determining subsequent effects to interoceptive processing, with further research needed to extend this support across different dimensions of interoception.

While laboratory-based manipulations provide detailed mechanistic insights, ecological validity is limited. As a result, it remains uncertain as to how momentary physical activity influences self-reported interoception in daily life. Further, although there is nascent research on the acute effects of physical activity on interoceptive processing, to the best of our knowledge there is currently no research on the momentary effects of sedentary behavior. In the present study we therefore used an ambulatory assessment to monitor momentary physical activity and sedentary behavior-induced daily variability in self-reported interoception. Considering previous research supporting the influence of baseline interoceptive accuracy on interoceptive perceptions during states of arousal (Füstös et al., 2013; Herbert et al., 2007; Köteles et al., 2020; Schillings et al., 2021), and further it's predictive power in explaining within-subject variability in interoception (Wittkamp et al., 2018), we also exploratorily tested whether interoceptive accuracy at baseline influenced perceptual sensitivity to these changes in activity. In addition to these more objectifiable measures, contextual information was recorded regarding the activity type to further investigate associations with different types of behaviors and to help unravel the importance of underlying attentional and physiological mechanisms.

As adaptive attention towards interoceptive processes has been found to aid both physical (Razon et al., 2010, 2014) and emotional (Mehling, 2016) regulation, this study aims to support existing research on the benefits of physical activity to more objectifiable dimensions of interoceptive processing, as well as reveal important information regarding the influence of everyday behaviors that could be used as guidance to promote and support self-reported interoception. Based on the theoretical underpinnings presented above, we developed two primary hypotheses and one exploratory hypothesis:

1) *Regarding within-subject variability, physical activity will relate to an increase in self-reported interoception, whereas sedentary behavior will relate to a decrease.*
    a. *Exploratory: Baseline interoceptive accuracy will influence changes in self-reported interoception in response to momentary physical activity and sedentary behavior.*

2) *Regarding activity type, different behavior categories (exercise, daily life physical activity, non-screen-based behavior, non-screen based social interactions, and sleeping) will display contrasting associations with self-reported interoception in comparison to the reference category screen time behavior.*

2. Methods

2.1. Participants

In total, 70 participants volunteered to take part in this study (Table 1). Recruitment took place across two time periods, May-June 2021, and October-December 2021, resulting in two cohorts of participants. The experiment was approved by the ethics committee of The University of Bern (Nr. 2021-07-00001) and conducted in accordance with the Declaration of Helsinki. All participants gave written informed consent prior to participation.

Table 1. *Descriptive statistics.* Parameters at baseline; age, gender, body mass index (BMI), and interoceptive accuracy (IAcc), as well as during the 7-day ambulatory assessment period; physical activity (millig – movement acceleration intensity) and sedentariness are displayed as means ± standard deviations. The number of answered prompts are given per activity type and as a percentage of the total number of prompts.

Variable	**Mean ± SD / *N*(% of total)**
Gender (Female)	33 (47.1%)
Age	21.67 ± 2.50
BMI	22.90 ± 2.31
Interoceptive accuracy (IAcc)	0.68 ± 0.24
Cohort	
May-June 2021	37 (52.9%)
Nov-Dec 2021	33 (47.1%)
Activity Type (number of cases)	
Screen time behavior	732 (34.6%)
Non-screen time behavior	266 (12.6%)
Non-screen-based social interactions	445 (21.1%)
Sleeping	92 (4.35%)
Daily life PA	374 (17.7%)
Exercise	204 (9.65%)

Variable	Mean ± SD / *N*(% of total)
Ambulatory assessment variables	
Average sedentariness across the last 15 minutes (0-15 minutes)	10.2 ± 5.60
Average sedentary minutes per day	498 ± 70.1
Average physical activity (millig) across the last 15 minutes	106 ± 149
Average physical activity (millig) across the week	109 ± 27.2
Average weekly self-reported interoception (0-35)	17.0 ± 5.08

2.2. Study procedure

Participants first visited the laboratory for baseline testing and familiarization with the ambulatory assessment procedure. On arrival, height (centimeters) and weight (kilograms) were taken, baseline questionnaires were completed and interoceptive accuracy (IAcc) was measured. Before leaving the laboratory, participants were introduced to the equipment [i.e., introduction to the movisensXS app (Movisens GmbH, Karlsruhe, Germany), how to answer the questionnaire, etc.], and they were equipped with a thigh-worn accelerometer which they were instructed to wear for seven consecutive days.

2.3. Baseline measures

Cardiac interoceptive ability

Cardiac interoceptive accuracy was operationalized here as the participants' performance in the Heartbeat Counting Task (HCT) (Schandry, 1981). After a practice interval of 20 s, there were three randomized trials (25, 35, and 45 s) separated by standard resting periods of 20 s (Ainley et al., 2014). During each trial, participants were given the following instructions: "Without manually checking, can you silently count each heartbeat you feel in your body from the time you hear "start" to when you hear "stop". Participants were seated throughout the task and were given no information as to the length of the intervals or their interoceptive accuracy scores. In addition, participants were strictly instructed not to guess the number of heartbeats, and to only count those they felt. The test supervisor signaled the beginning and the end of the counting phases by announcing "start" and "stop". Participants were asked to verbally report the number of counted heartbeats straight after the "stop" signal which was electronically recorded by the research team. Participants' heartbeats were recorded using the Polar Team^2 Pro mobile heart frequency monitor (Polar Electro Oy, Kempele, Finland). Validity and reliability compared to alternative electrocardiogram measurement devices have been supported in previous research (Radespiel-Tröger et al., 2003), and sensors were fitted loosely yet comfortably with the aim of reducing feedback from pulsatile sensations as much as possible. IAcc was deduced by averaging heartbeat perceptions score across the three trials, calculated according to the following equation:

$$\frac{1}{3}\Sigma\, 1 - \frac{(|n\text{beatsreal} - n\text{beatsreported}|)}{n\text{beatsreal}}$$

The heartbeat perception score typically takes on values from 0 to 1, where 1 depicts perfect accuracy. Confidence in their response was assessed at the end of each trial using a continuous visual analogue scale with verbal descriptors of "Total guess/No heartbeat awareness" and "Complete confidence/Full perception of heartbeat".

2.4. Ambulatory assessment

Ambulatory assessment is a state-of-the art approach including both device-based and self-reported repeated measurements of individuals in their natural environment to study behavioral and psychological processes (Trull & Ebner-Priemer, 2013). This does not only maximize ecological validity, but also minimizes recall bias (Heron & Smyth, 2010; Kim et al., 2013). This approach distinguishes between- and within-subject variability, with the latter allowing for the study of dynamic processes (Bolger & Laurenceau, 2013; Hoffman, 2014; Reichert et al., 2020). The following measurements were taken during the 7-day ambulatory assessment period.

2.4.1. Physical activity and sedentary behavior

The Move 4 accelerometer (Movisens GmbH, Karlsruhe, Germany) was used to continuously capture physical activity and sedentary behavior at a sampling frequency of 64 Hz. Raw acceleration data were stored on an internal memory card and were processed by a band pass filter (0.25 – 11 Hz) to eliminate artefacts. The Move 4 has been successfully used in previous physical activity-based studies where good user engagement, reliability, and validity has been demonstrated for experience sampling methods (Csikszentmihalyi & Larson, 1987; Fiedler et al., 2022; Giurgiu et al., 2022; Kanning et al., 2021; Reichert et al., 2020). We chose to place the sensor on the participants thigh as this position has been shown to be valid for the assessment of sedentary behavior using the Move 4 sensor (Giurgiu et al., 2020) and has been successfully implemented in large cohort studies for the assessment of 24-hour movement behaviors (Stamatakis et al., 2019). In addition, it also has been found to have better specificity and sensitivity for measuring physical activity and sedentary behavior compared to hip- and wrist-worn accelerometers (Montoye et al., 2016). The Move 4 was connected to smartphones which delivered accelerometry-triggered prompts to the participants during sedentary or active periods; after either a minimum of 10-minutes of light physical activity, or 30-minutes of uninterrupted sitting or lying. If none of the above conditions were fulfilled, random prompts were delivered. To avoid overburdening the participant, prompts were restricted to ten per-day, captured over 7 full days (7:30 am – 9:30pm). Participants were instructed to wear the sensors continuously for the whole intervention period and only to take it off for water-based activities (e.g., showering).

For the analysis, physical activity was calculated as the movement acceleration intensity (millig) aggregated across the last 15 minutes. According to sedentary behavior research, sitting or lying itself is not enough to be classified as sedentary, but the person must also have a low energy expenditure (less than 1.5 metabolic equivalents) (Tremblay et al., 2017). This means that any physical activity conducted in a sitting or lying position (e.g., cycling, rowing, sit-ups) would not be considered as sedentary. Hence, the average millig was calculated across all minutes where the body position was classified as sitting or lying. Based on previous research showing that walking activity starts at 350 millig, sedentary behavior was determined as a lying or sitting body position with less than two standard deviations above the average millig across all sitting/lying minutes, corresponding to less than 187 millig in this dataset. This means that 4.0% of the cases categorized as sitting/lying by the sensor were re-classified as non-sedentary.

2.4.2. Activity type

Considering the suggested importance of attentional mechanisms, we further aimed to elucidate contextual information regarding the type of activity performed. In other words, certain activities might cultivate attentional capacity to attend to the internal body more than others. For example, it is possible that performing goal-oriented exercise is more likely to direct attention to the state and form of the body than when performing more automized daily life physical activities (Toner et al., 2016). Identifying differences resulting from varying characteristics of behavior could therefore reveal important mechanistic information regarding the proposed play off between attentional and physiological mechanisms in physical activity-related influences on interoceptive processing; indexed here at the self-reported level. Furthermore, it is becoming increasingly clear that the quality and context of sedentary behavior is important to consider (Kanning et al., 2021). To address this, we asked participants, "What have you been doing mostly in the last 15 minutes". Response options were chosen using previous studies (Cabanas-Sánchez et al., 2018; Giurgiu et al., 2022; Hallgren et al., 2020), yet due to the large number of activity options, for the present study the response options were collapsed into the following relevant categories as a factorized predictor variable with six levels, including: 1) screen time behavior (e.g., watching a video, using social media, being in a zoom meeting) 2) non-screen time (usually sedentary) activities (e.g., reading, relaxing, eating), 3) non-screen based social activities (e.g., talking to somebody on the phone, meeting in-person), 4) sleeping, 5) daily life physical activities (e.g., cycling to commute, household work), and 6) exercise (Please see also supplementary material 1).

2.4.3. Self-reported interoception

Self-reported interoception was measured using the 6-item body subscale of The State Mindfulness Scale (SMS) (Tanay & Bernstein, 2013). The SMS aims to quantify the participants' perception of their present experience during the past 15 minutes. More specifically, it aims to capture the subjective levels of present attention to and awareness of bodily sensations. Items include, "I noticed physical sensations come and go", and "I felt in contact with my body". Responses were given on a 5-point Likert scale ranging from 1 (not at all) to 5 (very well). Although the SMS was not originally developed as an explicit measure of interoception, the body subscale draws parallels with interoceptive processes, centered around the non-judgmental noticing of bodily sensations. Furthermore, the SMS represents a suitable option to detect small changes in the bodily state, as one of the few validated questionnaires measuring state changes in bodily perceptions. The body subscale has previously shown good internal consistency (Cronbach's $\alpha = .89$) (Tanay & Bernstein, 2013). We assessed within-person variability of the scale using multilevel confirmatory factor analysis (MLCFA) which is based upon generalizability theory (Cranford et al., 2006; Geldhof et al., 2014). Here we calculated multilevel composite reliability (ω) using the "lavaan" package (Rosseel et al., 2023). The scale showed a high degree of within-person (ω_{within} = 0.92) and between-person ($\omega_{between}$ = 0.97) reliability. Detailed results regarding within- and between-person factor loading and model fit are presented in supplement 2.

2.5. Statistical analysis

All data were pre-processed using SPSS version 27 (SPSS Inc., Chicago, IL, USA) and R Project version 4.2.0 (R Core Team, 2021). Due to the hierarchical structure of the data, multi-level models were used (Bolger & Laurenceau, 2013) with self-reported interoception (level 1) nested in participants (level 2) to identify the within- and between-subjects effects. The package "nlme" (Pinheiro et al., 2021) was used with a covariance matrix with continuous autocorrelation structure. A hierarchical approach was used for the inclusion of the control variables and the model fit was assessed with -2 restricted log-likelihood and the Akaike information criterion (AIC). Model assumptions were visually inspected using the package "performance" (Lüdecke et al., 2021), with no considerable violations detected. A 15-minute time frame was chosen as previous ambulatory assessment studies have demonstrated that this timeframe is highly relevant for momentary psychological constructs in physical behavior (Giurgiu et al., 2019; Reichert et al., 2017; Schwerdtfeger et al., 2010). The intra-class correlation coefficient (ICC) was calculated using unconditional models which provides information regarding how much of the self-reported interoception is explained within- and between-person (Bolger & Laurenceau, 2013). In the next step, a model was set up to investigate the main effects of physical activity, sedentary behavior, and activity type: First, the predictors physical activity (millig) and sedentary behavior in the last 15 (dimensional variable ranging from 0-15) were person-mean centered and added as level-1 variables to the model. Second, baseline interoceptive accuracy (IAcc), average sedentary behavior across the study week, and average physical activity (millig) across the study week were grand mean centered and added to the model. Third, the predominant activity type performed in the 15-minutes prior to the prompt was recorded to unravel potential differences between different behavior types. Activity type was treated as a factorized predictor variable, and since we expected screen time behavior to be the most detrimental to self-reported interoception considering the literature discussed above, we set screen time sedentary behavior as the reference category and compared this to non-screen time behavior (which predominantly consists of sedentary activities), non-screen-based social interactions, daily life physical activity, exercise, and sleeping. Fourth, the following control variables were entered one by one into the model but were only kept in the main model if the model fit improved: gender, BMI, age, time, time squared, week-part (weekday [Monday-Friday] and weekend [Saturday-Sunday]) and cohort (Cohort 1: May-July 2022; Cohort 2: November-December 2022). In a second model, we added interactions between baseline interoceptive accuracy and both physical activity and sedentary behavior to explore potential influences on those relationships. If the interactions were significant, we added another interaction model in which participants were grouped into tertiles based on their baseline interoceptive accuracy scores. This was done to determine more robust conclusions regarding the direction of the interactions with each of the interoceptive accuracy tertiles. The 3rd tertile representing the highest interoceptive accuracy score was set as the reference category, which was then compared against the 2nd (medium) and 1st (low) interoceptive accuracy tertiles. Interactions were then plotted based on the interaction model with predicting values using the package "ggeffects" (Lüdecke, 2018). All result tables of multi-level models were generated using the package "sjPlot" (Lüdecke et al., 2022).

3. Results

3.1. Associations between physical activity, sedentary behavior, and self-reported interoception

For the state self-reported interoception score, the ICC indicated that 51% of the variance was attributable to between-person differences. ***Within-subject.*** Results show that each one-minute increase in sedentary behavior was associated with a 0.06-point decrease in self-reported interoception (B = -0.06, p = .009). Translating this into an example based on the unstandardized beta coefficient: if a person was consistently sedentary for 15 minutes, self-reported interoception decreased by 0.90 points (scale range = 0 – 35). Contrastingly, each one-millig increase in physical activity was associated with an increase in self-reported interoception (B = 0.0025, p = .013). Translating this into an example: If a person engaged in on average 350 millig (which is considered the threshold for walking, see Ebner-Priemer et al., 2013) across the last 15 minutes prior to the e-diary prompt, self-reported interoception increased by 0.88 points. **Between-subject.** Results indicate that higher levels of weekly physical activity were associated with lower self-reported interoception (B= -0.05, p <.001). Conversely, results showed no significant between-subject effects of average weekly sedentariness (B = -0.11, p = .179) (Table 2).

Table 2. *Multi-level model main effects analyses.*

Predictors	*B*	*std. Error*	*β*	*CI*	*t-value*	*p*
(Intercept)	16.06	0.40	-0.19	15.27 – 16.85	39.75	**<.001**
Sedentariness across the last 15 minutes within-person (acute)	-0.06	0.02	-0.06	-0.10 – -0.01	-2.62	**.009**
Average weekly sedentariness between-subject	-0.01	0.01	-0.11	-0.02 – 0.00	-1.37	.175
Millig across the last 15 minutes within-person (acute)	0.0025	0.00	0.07	0.00 – 0.00	2.50	**.013**
Average weekly millig between-subject	-0.05	0.01	-0.29	-0.08 – -0.03	-3.80	**<.001**
Baseline interoceptive accuracy	4.50	1.60	0.21	1.31 – 7.69	2.81	**.007**
Activity type – (Reference category = Screen-time behavior)						
Non-screen-time behavior	0.67	0.23	0.13	0.21 – 1.13	2.86	**.004**
Non-screen-based social interactions	1.13	0.21	0.22	0.73 – 1.54	5.45	**<.001**
Sleeping	-1.73	0.35	-0.34	-2.41 – -1.05	-4.94	**<.001**
Daily life physical activity	1.21	0.24	0.24	0.74 – 1.68	5.02	**<.001**
Exercise	4.48	0.31	0.88	3.88 – 5.08	14.60	**<.001**
Random effects						
σ^2	9.90					
$\tau_{00\ \text{Participant}}$	9.91					
$\tau_{11\ \text{Participant.millig\_15\_ws}}$	0.00					
$\tau_{11\ \text{Participant.Sedentariness3\_15\_minutes\_ws}}$	0.00					
ρ_{01}	0.14					
	-0.40					
ICC	0.51					
$N_{\text{Participant}}$	70					

All results are displayed using the unstandardized Beta (B), with the number displayed showing the change in self-reported interoception if the independent variable (e.g., sedentary behavior) changes by one unit (e.g., one minute); the standardized beta (β) which as calculated using the package "sjPlot" by refitting the model on the standardized data (Lüdecke, 2022), 95% confidence intervals for the unstandardized Beta coefficient

(CI), the t-value, and the p-value (p), where bold values indicate p = <.05. The within-person residuals (σ^2), the between-person intercept (τ_{00}) and slope (τ_{11}) variance, the intraclass correlation coefficient (ICC), first-order autocorrelations (ρ_{01}), and the number of participants (N) included in the analysis are also displayed. Variables were grand mean centered.

3.2. The influence of baseline interoceptive accuracy on the associations between physical activity, sedentary behavior, and self-reported interoception.

From the main effects multi-level model, higher interoceptive accuracy (IAcc) at baseline was associated with an increase in daily self-reported interoception (*B* = 4.51, *p* = .007) (Table 1). We therefore performed an additional exploratory model including interactions between baseline IAcc and both physical activity and sedentary behavior (Supplementary 3). Results from an additional model revealed a significant interaction between baseline IAcc and acute physical activity (marked as the behavior performed in the last 15 minutes prior to the prompt) (*B* = -0.01, *p* = .004). There were no significant interaction effects between baseline IAcc and acute sedentary behavior. To allow for more robust conclusions, we set up another model with participants grouped into tertiles based on their baseline interoceptive accuracy scores (see Supplementary 4 for descriptives), adding an interaction between the IAcc tertile groups and acute physical activity with the participants in the highest tertile set as the reference category. The interaction revealed that compared to the participants in the highest tertile (3^{rd}), the association was different for participants in the medium (2^{nd}) (*B* = 0.005, *p* = .002) and the lowest (1^{st}) tertile (*B* = 0.005, *p* = .004) (Supplementary 5). Graphical visualizations of the data reveal that for individuals in the 1^{st} and 2^{nd} IAcc tertile, acute physical activity was associated with increases in self-reported interoception compared to individuals in the 3^{rd} tertile who were associated with decreases (Figure 1).

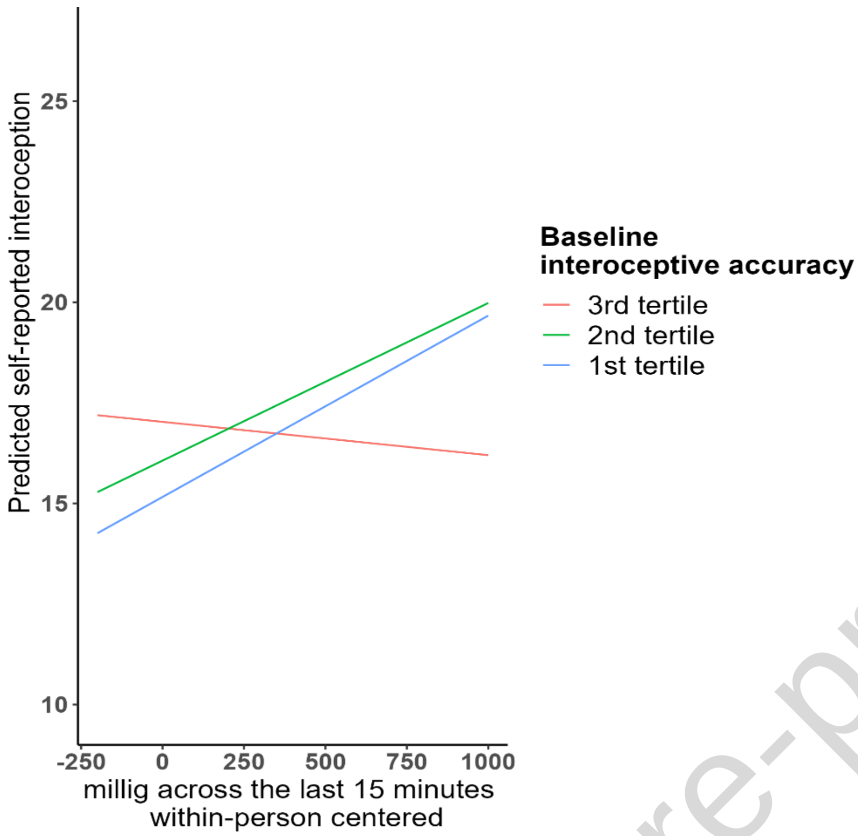

Figure 1. *Model-based predictions of interactions between baseline interoceptive accuracy and acute physical activity (millig – milligravity units of acceleration) on self-reported interoception.* Predicted patterns of self-reported interoception displaying interactions between acute physical activity and baseline interoceptive accuracy scores (IAcc) split into tertiles. The red line represents the 3rd (high scores) tertile, the green line represents the 2nd (medium scores) tertile, and the blue line represents the 1st (low scores) tertile. Individuals in the 1st and 2nd tertile are associated with increases in self-reported interoception after acute physical activity, whereas individuals in the 3rd tertile are associated with decreases (please note the y-axis only runs through 10-25 for predicted self-reported interoception scores – actual scale: 0-35).

3.3. Associations between activity type and self-reported interoception

Compared to the reference category screen time behavior, both partaking in exercise (B = 4.48, p <.001) and daily life physical activity (B = 1.21, p <.001) were associated with improved self-reported interoception. Regarding the other behavior categories, both non-screen time behavior (B= 0.67, p = .004) and non-screen-based social interactions (B = 1.13, p <.001) were associated with an increase in self-reported interoception compared to screen time behavior. Compared to screen time behavior, sleeping was associated with lower self-reported interoception (B = -1.73, p <.001) (see also Table 2 and Figure 2).

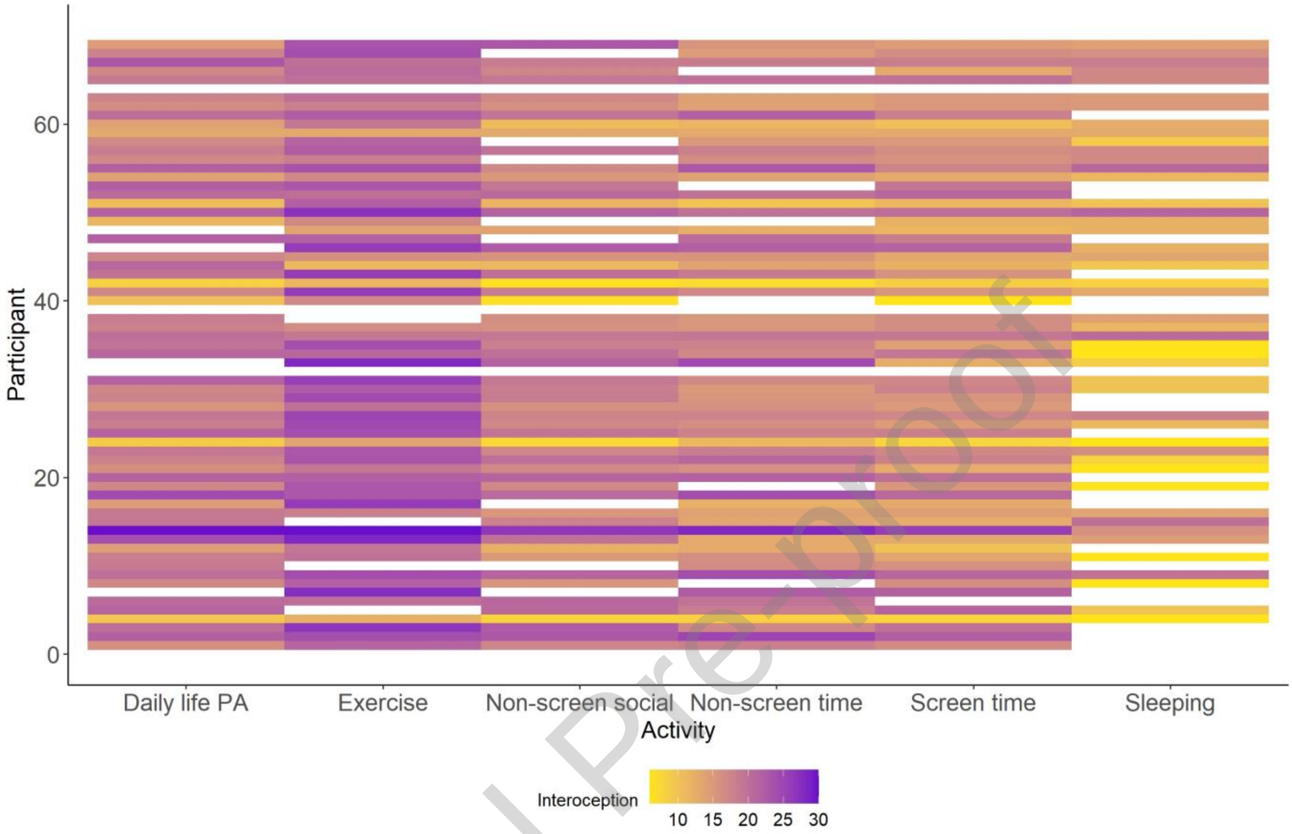

Figure 2. *A heatmap displaying differences in self-reported interoception between different activity types.* Scores are displayed on a color gradient, with darker purple indicative of higher self-reported interoceptive attention, and lighter yellow indicative of lower self-reported interoceptive attention. Activity types included are daily life physical activity, exercise, non-screen time sedentary behavior, social non-screen time sedentary behavior, screen time sedentary behavior, and sleeping.

4. Discussion

This study used ambulatory assessment, applying movement-triggered e-diary prompts to evaluate within- and between-subject effects of physical activity and sedentary behavior on self-reported interoception in daily life. Our results showed that momentary physical activity was associated with an increase in self-reported interoception, while in contrast, sedentary behavior was associated with a decrease. Exploratory interactions revealed that baseline interoceptive accuracy influenced relationships with physical activity, where model-based predictions revealed low and medium baseline interoceptive accuracy (IAcc) scores to be associated with increases in self-reported interoception, contrasted to observed decreases with high IAcc. Activity type also mattered, whereby in comparison to screen-time behavior, partaking in exercise was associated with a higher increase in self-reported interoception than daily life physical activities. Similarly, non-screen time behavior was associated with higher self-reported interoception than screen-time behavior, with an even greater difference found for non-screen-based social interactions.

Conceptually, the increase in self-reported interoception following momentary physical activity may be explained by the fact that during physical activity, sympathetic nervous system activation increases the salience of interoceptive cues beyond resting-state boundaries (Ekkekakis & Acevedo, 2006), thus making our bodily signals more noticeable. Alternatively, the cue utilization hypothesis posits that as physiological arousal increases, the number of cues that can be utilized decreases, resulting in the subsequent filtering of irrelevant stimuli in the environment (Easterbrook, 1959). This increased arousal therefore allows interoceptive sources of information to dominate space in our consciousness, narrowing attentional resources to focus on internal physiological signals (Schulz & Vögele, 2015). The results of the present study vuild on findings from previous laboratory-based studies (Antony et al., 1995; Jones & Hollandsworth, 1981; Montgomery et al., 1984; Wallman-Jones et al., 2022), demonstrating how momentary physical activity can influence interoceptive perceptions in a real-world setting, represented here by changes in self-reported interoception. Considering the growing need for interoceptive interventions (Weng et al., 2021), these findings show support for and provide guidance for the use of physical activity-based interventions to support interoceptive processes.

In contrast to the effects of physical activity, momentary sedentary behavior was associated with a decrease in self-reported interoception. The negative effects of sedentary behavior to emotional, social, and physical health have been widely reported (Beauchamp et al., 2018), however little is known about influences on interoceptive processing. Despite this, it is widely known that stimulation is essential for growth of any perceptual processing system (Livingston et al., 2020). It would therefore be logical to assume the same principle applies with interoceptive mechanisms, which can be seen in the way physically trained and sedentary individuals have been found to differ in their neural processing of heartbeats (Perakakis et al., 2017), or similarly how BMI and physical activity participation has been found to predict interoceptive abilities (Georgiou et al., 2015; Mölbert et al., 2016; Robinson et al., 2021). This was further supported by our findings, where even momentary states of sedentary behavior are associated with decreases in interoceptive processing at the self-report level. These findings add to the body of research indicating the contrasting effects resulting from sedentary behavior, whereby recommendations to reduce physical inactivity should be reconsidered to incorporate interoceptive pathways.

There is growing evidence for the importance of context when considering sedentary behavior. For example, sitting during leisure time has been associated with higher affect than sitting during work, and similarly, sitting during social interactions has been associated with higher affect than sitting alone (Kanning et al., 2021). This principle is further supported by the way that different interoceptive dimensions can be increased with sedentary interoceptive attention-based manipulations (Ainley et al., 2012, 2013; Fischer et al., 2017). Supporting this notion, indeed activity type mattered in the present study, where in comparison to screen time behaviors, non-screen time behaviors were associated with an increase in self-reported interoception. This could be explained by the competition of cues hypothesis, where it is stated that attention to one source of information diminishes attentional resources to other sources of information (Pennebaker & Lightner, 1980). In this context, focused attention towards screen-based activities may come at the expense of interoceptive cues. As such, while previous research found screen time behavior has been associated with negative implications to neural levels of interoceptive processing (Paik et al., 2019), this might not be generalizable to all sedentary behaviors. Interestingly, this increase was accentuated further during non-screen-based social interactions. Interoception is rooted in socialization, beginning with early interactions with caregivers (Oldroyd et al., 2019), to the establishment of self-other distinctions later in life (Palmer & Tsakiris, 2018). This finding therefore reiterates the embodied benefits of social interactions, supplementing what is already known regarding the psychological risks of isolating behaviors (Elovainio et al., 2017). Together this supports the importance of attentional mechanisms, where our findings elucidate to the fact that the direction and demand of attention during the activity is an important factor to consider with regards to subsequent effects to self-reported interoception, not just the intensity alone.

Regarding physical activity, similar patterns were observed, whereby exercise was related to higher self-reported interoception compared to screen-time behavior than daily life physical activities e.g., walking upstairs, cleaning etc. This could be seen to emulate the importance of attentional mechanisms, whereby during exercise, there is a heightened focus on the body, whether that is in the monitoring of breathing to pace exertion, or in the positioning of the limbs in executing a movement sequence (Toner et al., 2016). Conversely, automized daily physical activities often have an external oriented attentional focus, reducing the attentional capacity to focus on the body. Alternatively, these effects could be explained by the intensity of the activity. As mentioned earlier, physical activities of a higher intensity are considered more likely to elicit adaptations to interoceptive processing, representing an intensity-dependent relationship (Ekkekakis, 2003, 2009). It could be assumed that activities in the exercise category are likely to be of a higher intensity than daily physical activities, which are often characterized by light-moderate intensities (Brooks et al., 2004). If true, this would instead highlight the importance of the salience of the physiological signals, rather than the attention towards them. However, as intensity was not accounted for in the present study, we can only speculate. Further research investigating the intensity-dependent patterns would therefore reveal important information regarding the play off between the physiological and attentional mechanisms.

Exploratory interactions revealed a significant relationship between within-subject physical activity and baseline IAcc, suggesting that individual differences in sample characteristics may influence perceptual responses to physiological perturbations. Model-based predictions of these interactions found low and medium IAcc scores at baseline to be associated with increased self-reported interoception in response to momentary physical activity, whilst contrastingly high IAcc scores were associated with a decrease. These findings reflect previous laboratory-based studies using behavioral measures of interoception, where individuals with higher IAcc at baseline were less likely to experience physical activity-related increases in their IAcc, with some even experiencing decreases (Wallman-Jones et al., 2022). As mentioned earlier in the context of physical activity participation, having a higher accuracy in interoceptive perceptions might reduce the perceived sensitivity to physiological changes due to the familiarity of the signals, whereby more objectifiable interoceptive abilities at rest influence more subjective perceptions in response to perturbations (Marshall et al., 2018). Alternatively, these patterns could also be explained by a potential ceiling effect, whereby those with higher interoceptive abilities at baseline have little room for improvement across dimensions. While the exact mechanism is uncertain, this highlights interesting patterns that replicate previous findings, demonstrating how individual differences at baseline might influence responses across different interoceptive dimensions in response to perturbations. It should be noted, however, that these exploratory findings should be considered with caution, where the sample size used may not be sufficient to accurately measure cross-level interactions. Future studies using well-powered designs to address these differential effects are therefore warranted.

In contrast to our within-subject findings, between-subject analyses revealed that higher physical activity performed across the week was associated with a decrease in self-reported interoception. While at first these findings appear to oppose our original hypothesis, these differences could be explained by the dimensions of interoception measured. Previous associations between habitual physical activity and interoceptive processing were found using more objectifiable behavioral measures of interoception (Georgiou et al., 2015; Mölbert et al., 2016), whereas in the present study, self-report measures were used. Whilst repeated exposure to salient signals could improve the accuracy in perception due to the increased familiarity, this may not translate across all dimensions of interoception. Conversely, at the most basic, self-report level, there might be a habituation effect, whereby repeated exposure to signals of arousal reduces perceived sensitivity to these changes over time. In other words, individuals who are more physically active become accustomed to exercise-induced changes in the body, freeing up attentional resources towards external stimuli (Marshall et al., 2022). This complements previous findings whereby elite athletes showed attenuated activation of the anterior insula cortex in response to aversive interoceptive stimulation, which was hypothesized to reflect how experience in physical activity translates to experience in adapting to physiological perturbations (Paulus et al., 2012). Interestingly, the anterior insular cortex has been proposed to regulate attention towards physiological signals (Wang et al., 2019), which undoubtedly plays a role in self-reported indices of interoception. This reduction in self-reported interoception in the present study may therefore represent an adaptive shift in attentional mechanisms that should be investigated in further research, whereby optimum values of interoception may differ depending on the dimension measured, the individual, and the context.

This study does not come without limitations. Despite using behavioral tests to measure baseline interoceptive ability, we relied on self-report in measuring momentary interoception across the 7-days. Whilst self-reported indices of interoception are gaining increased importance for their role in mental health (Nord & Garfinkel, 2022), alone they do not paint a full picture of the hierarchical nature of interoceptive processing. Considering the dissociable dimensions of interoception and the importance of their correspondence to self-regulation (Garfinkel, Tiley, et al., 2016), additional objectifiable measures should be included to see if findings translate across all levels of processing. In discussing the use of behavioral tests to measure interoception, however, their validity should also be discussed. In the present study, IAcc was indexed by scores from the widely used heartbeat counting task, however, it should be noted that the validity of this task has been questioned in previous research (Adams et al., 2022; Corneille et al., 2020; Desmedt et al., 2022). Findings of the present study should be interpreted with consideration that scores may not reflect a purely objectifiable measure of IAcc due to undoubtable influences of subjective perceptions (Desmedt et al., 2018).

As stated in the methods, the questionnaire used to measure self-reported interoception was not explicitly designed for this purpose. This may present problems, whereby items vary in their relatedness to the construct in question. For example, the item: ‘I noticed various sensations caused by my surroundings (e.g., heat, coolness, the wind on my face)’ is likely to involve exteroceptive perceptions. It should also be noted that more recent classifications differentiate self-reported interoception into of categories of accuracy and attention (Gabriele et al., 2022; Murphy et al., 2020). Considering the items of the State Mindfulness Scale (body subscale), questions could be considered to crossover the domains of both self-reported accuracy (e.g., I clearly physically felt what was going on inside my body) and attention (e.g., I noticed physical sensations come and go). In light of the proposed distinctions between these two domains, it is unclear from our findings what factor is being represented in the results. Future research would therefore benefit from the development of validated self-reported interoception questionnaires adapted to measure state changes, acknowledging the different domains of accuracy and attention. In addition to the suggested improvements to the included self-reported interoception questionnaire, the inclusion of non-interoceptive control questionnaires would allow for a more confident attribution of the findings to interoceptive processes.

Regarding our between-subject physical activity measure, differing intensities were not considered. It has been suggested that physical activity influences interoceptive processing in an intensity-dependent manner (Williamson et al., 1997, 1999). This is outlined in the dual-mode theory of exercise, where it is proposed that attentional resources shift in dominance from cognitive to interoceptive cues around the point of the anaerobic threshold (Ekkekakis, 2003). Similarly for sedentary behavior, it is becoming increasingly accepted that context matters (Kanning et al., 2021), supported by the differentiation between activity type in the present study. This is further reflected in the ability for sedentary, attention-based manipulations to increase interoceptive ability (Ainley et al., 2012, 2013; Fischer et al., 2017). It could therefore be possible that averaging across activity types and intensities may mask effects. For example, the negative effects of screen-time behavior might be mitigated by alternative sedentary activities, such as reading a book, chatting to a friend, or meditating. Further research should therefore investigate whether controlling for intensity and context alters the effects of weekly physical activity and sedentary behavior.

Regarding sedentary behavior scores, it is unclear which millig cut-off qualifies as light physical activity. Based on previous research (Ebner-Priemer et al., 2013), millig during sedentary behavior is between 100-350. Additional models were therefore calculated to investigate whether our results remained stable using other cut-offs; with sedentariness defined as body position equals sitting or lying and a) without considering the millig; b) physical activity less than 100 millig, and c) physical activity less than 350 millig (Supplementary 6). The results remained stable when using the body position in combination with the 100 millig but were not significant anymore for sedentary behavior across the last 15 minutes when either only the body position or the combination with 350 millig cut-off were used. However, in all three cases, the directions of the results remained the same. Hence, future validation studies are warranted considering both the body position and the physical activity level to determine sedentary behavior.

Finally, due to lack of relevant prior research, we did not conduct an a-prior power calculation. However, based on previous ambulatory assessment studies with mood as a commonly investigated psychological construct in relation to movement behaviors (Liao et al., 2015), we are confident that our sample size was sufficient to detect within-person associations, and future studies may use these results to conduct an a-priori power calculation.

5. Conclusion

The findings from this study extend from previous research, demonstrating the contrasting associations between momentary physical activity and sedentary behavior with self-reported interoception in daily life, influenced by individual differences. Considering activity type, differing contexts and characteristics appear to significantly influence self-reported interoception, particularly highlighting the importance of reducing participation in screen-time behaviors to preserve and support interoceptive perceptions. Together this sheds further light on the potential underlying interactions between attentional and physiological mechanisms, supporting the shared influences of attention towards bodily signals and the salience of the signals themselves. Findings can be used to inform individualized health recommendations for reducing screen-time behavior and guiding evidence-based physical activity interventions to promote interoceptive processes.

Declarations

Ethics approval and consent to participate

The experiment was approved by the ethics committee of The University of Bern (Nr. 2021-07-00001) and conducted in accordance with the Declaration of Helsinki. All participants gave written informed consent prior to participation.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

No funding to declare.

Author contributions

AWJ and MS conceptualized the study. AWJ, MS, and CN developed the methodology. CN and AWJ were the project administrators, conducted the investigation, and prepared the data. CN was responsible for the formal analysis, AWJ and CN were responsible for data visualization. AWJ wrote the original draft of the manuscript. AWJ, CN, and VB edited the manuscript. MS and VB provided resources and supervised the work.

Statement: The authors did not use generative AI technologies for preparation of this work.

References

Adams, K. L., Edwards, A., Peart, C., Ellett, L., Mendes, I., Bird, G., & Murphy, J. (2022). The association between anxiety and cardiac interoceptive accuracy: A systematic review and meta-analysis. *Neuroscience & Biobehavioral Reviews*, *140*, 104754. https://doi.org/10.1016/J.NEUBIOREV.2022.104754

Ainley, V., Brass, M., & Tsakiris, M. (2014). Heartfelt imitation: High interoceptive awareness is linked to greater automatic imitation. *Neuropsychologia*, *60*(1), 21–28. https://doi.org/10.1016/j.neuropsychologia.2014.05.010

Ainley, V., Maister, L., Brokfeld, J., Farmer, H., & Tsakiris, M. (2013). More of myself: Manipulating interoceptive awareness by heightened attention to bodily and narrative aspects of the self. *Consciousness and Cognition*, *22*(4), 1231–1238. https://doi.org/10.1016/j.concog.2013.08.004

Ainley, V., Tajadura-Jiménez, A., Fotopoulou, A., & Tsakiris, M. (2012). Looking into myself: Changes in interoceptive sensitivity during mirror self-observation. *Psychophysiology*, *49*(11), 1672–1676. https://doi.org/10.1111/j.1469-8986.2012.01468.x

Antony, M. M., Brown, T. A., Craske, M. G., Barlow, D. H., Mitchell, W. B., & Meadows, E. A. (1995). Accuracy of heartbeat perception in panic disorder, social phobia, and nonanxious subjects. *Journal of Anxiety Disorders*, *9*(5), 355–371. https://doi.org/10.1016/0887-6185(95)00017-I

Beauchamp, M. R., Puterman, E., & Lubans, D. R. (2018). Physical Inactivity and Mental Health in Late Adolescence. *JAMA Psychiatry*, *75*(6), 543. https://doi.org/10.1001/jamapsychiatry.2018.0385

Bolger, N., & Laurenceau, J. P. (2013). *Intensive longitudinal methods: An introduction to diary and experience sampling research.* . Guildford Press. https://psycnet.apa.org/record/2012-17340-000

Borg, G. A. (1982). Psychophysical bases of perceived exertion. *Medicine and Science in Sports and Exercise*, *14*(5), 377–381. http://www.ncbi.nlm.nih.gov/pubmed/7154893

Brooks, A. G., Withers, R. T., Gore, C. J., Vogler, A. J., Plummer, J., & Cormack, J. (2004). Measurement and prediction of METs during household activities in 35- to 45-year-old females. *European Journal of Applied Physiology*, *91*(5–6), 638–648. https://doi.org/10.1007/S00421-003-1018-9/FIGURES/4

Cabanas-Sánchez, V., Guallar-Castillón, P., Higueras-Fresnillo, S., García-Esquinas, E., Rodríguez-Artalejo, F., & Martinez-Gomez, D. (2018). Physical activity, sitting time, and mortality from inflammatory diseases in older adults. *Frontiers in Physiology*, *9*(JUL), 898. https://doi.org/10.3389/fphys.2018.00898

Cannon, W. B. (1927). The James-Lange Theory of Emotions: A Critical Examination and an Alternative Theory. *The American Journal of Psychology*, *39*(1/4), 106. https://doi.org/10.2307/1415404

Caspersen, C., Powell, K., & Christenson G. (1985). Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Reports*, *100*(2), 126.

Corneille, O., Desmedt, O., Zamariola, G., Luminet, O., & Maurage, P. (2020). A heartfelt response to Zimprich et al. (2020), and Ainley et al. (2020)'s commentaries: Acknowledging issues with the HCT would benefit interoception research. In *Biological Psychology* (Vol. 152). Elsevier B.V. https://doi.org/10.1016/j.biopsycho.2020.107869

Cranford, J. A., Shrout, P. E., Iida, M., Rafaeli, E., Yip, T., & Bolger, N. (2006). A procedure for evaluating sensitivity to within-person change: Can mood measures in diary studies detect change reliably? *Personality and Social Psychology Bulletin*, *32*(7), 917–929. https://doi.org/10.1177/0146167206287721

Critchley, H. D., & Garfinkel, S. N. (2017). Interoception and emotion. *Current Opinion in Psychology*, *17*, 7–14. https://doi.org/10.1016/j.copsyc.2017.04.020

Cronbach, L. J., Rajaratnam, N., & Gleser, G. C. (1963). Theory of generalizability: A liberalization of reliability theory. *British Journal of Statistical Psychology*, *16*(2), 137–163. https://doi.org/10.1111/J.2044-8317.1963.TB00206.X

Csikszentmihalyi, M., & Larson, R. (1987). Validity and reliability of the Experience-Sampling Method. *The Journal of Nervous and Mental Disease*, *175*(9), 526–536. https://doi.org/10.1097/00005053-198709000-00004

Desmedt, O., Luminet, O., & Corneille, O. (2018). The heartbeat counting task largely involves non-interoceptive processes: Evidence from both the original and an adapted counting task. *Biological Psychology*, *138*, 185–188. https://doi.org/10.1016/j.biopsycho.2018.09.004

Desmedt, O., van den Houte, M., Walentynowicz, M., Dekeyser, S., Luminet, O., & Corneille, O. (2022). How Does Heartbeat Counting Task Performance Relate to Theoretically-Relevant Mental Health Outcomes? A Meta-Analysis. *Collabra: Psychology*, *8*(1). https://doi.org/10.1525/COLLABRA.33271

Easterbrook, J. A. (1959). The effect of emotion on cue utilization and the organization of behavior. *Psychological Review*, *66*(3), 183–201. https://doi.org/10.1037/H0047707

Ebner-Priemer, U. W., Koudela, S., Mutz, G., & Kanning, M. (2013). Interactive multimodal ambulatory monitoring to investigate the association between physical activity and affect. *Frontiers in Psychology*, *3*(JAN), 596. https://doi.org/10.3389/FPSYG.2012.00596/BIBTEX

Ekkekakis, P. (2003). Pleasure and displeasure from the body: Perspectives from exercise. *Cognition and Emotion*, *17*(2), 213–239. https://doi.org/10.1080/02699930302292

Ekkekakis, P. (2009). The dual-mode theory of affective responses to exercise in metatheoretical context: II. bodiless heads, ethereal cognitive schemata, and other improbable dualistic creatures, exercising. *International Review of Sport and Exercise Psychology*, *2*(2), 139–160. https://doi.org/10.1080/17509840902829323

Ekkekakis, P., & Acevedo, E. (2006). Psychobiology of physical activity. In *Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*. Human Kinetics. http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:No+Title#0%5Cnhttp://books.google.com/books?hl=en&lr=&id=hLHgpz6D_gAC&oi=fnd&pg=PR9&dq=Psychobiology+of+physical+activity&ots=1BTMvOii8N&sig=sE2Htr0gbsIsXs4Xse1JOabgxTI

Elovainio, M., Hakulinen, C., Pulkki-Råback, L., Virtanen, M., Josefsson, K., Jokela, M., Vahtera, J., & Kivimäki, M. (2017). Contribution of risk factors to excess mortality in isolated and lonely individuals: an analysis of data from the UK Biobank cohort study. *The Lancet Public Health*, *2*(6), e260–e266. https://doi.org/10.1016/S2468-2667(17)30075-0

Fiedler, J., Seiferth, C., Eckert, T., Woll, A., & Wunsch, K. (2022). Sleep quality, valence, energetic arousal, and calmness as predictors of device-based measured physical activity during a three-week mHealth intervention: An ecological momentary assessment study within the SMARTFAMILY trial. *German Journal of Exercise and Sport Research*, *52*(2), 237–247. https://doi.org/10.1007/S12662-022-00809-Y/TABLES/3

Fischer, D., Messner, M., & Pollatos, O. (2017). Improvement of Interoceptive Processes after an 8-Week Body Scan Intervention. *Frontiers in Human Neuroscience*, *11*, 452. https://doi.org/10.3389/fnhum.2017.00452

Füstös, J., Gramann, K., Herbert, B. M., & Pollatos, O. (2013). On the embodiment of emotion regulation: Interoceptive awareness facilitates reappraisal. *Social Cognitive and Affective Neuroscience*, *8*(8), 911–917. https://doi.org/10.1093/scan/nss089

Gabriele, E., Spooner, R., Brewer, R., & Murphy, J. (2022). Dissociations between self-reported interoceptive accuracy and attention: Evidence from the Interoceptive Attention Scale. *Biological Psychology*, *168*. https://doi.org/10.1016/J.BIOPSYCHO.2021.108243

Garfinkel, S. N., Manassei, M. F., Hamilton-Fletcher, G., den Bosch, Y. I., Critchley, H. D., & Engels, M. (2016). Interoceptive dimensions across cardiac and respiratory axes. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *371*(1708), 20160014. https://doi.org/10.1098/rstb.2016.0014

Garfinkel, S. N., Seth, A. K., Barrett, A. B., Suzuki, K., & Critchley, H. D. (2015). Knowing your own heart: Distinguishing interoceptive accuracy from interoceptive awareness. *Biological Psychology*, *104*, 65–74. https://doi.org/10.1016/j.biopsycho.2014.11.004

Garfinkel, S. N., Tiley, C., O'Keeffe, S., Harrison, N. A., Seth, A. K., Critchley, H. D., O 'keeffe, S., Harrison, N. A., Seth, A. K., & Critchley, H. D. (2016). Discrepancies between dimensions of interoception in autism: Implications for emotion and anxiety. *Biological Psychology*, *114*, 117–126. https://doi.org/10.1016/j.biopsycho.2015.12.003

Geldhof, G. J., Preacher, K. J., & Zyphur, M. J. (2014). Reliability estimation in a multilevel confirmatory factor analysis framework. *Psychological Methods*, *19*(1), 72–91. https://doi.org/10.1037/A0032138

Georgiou, E., Matthias, E., Kobel, S., Kettner, S., Dreyhaupt, J., Steinacker, J. M., & Pollatos, O. (2015). Interaction of physical activity and interoception in children. *Frontiers in Psychology*, *6*(APR), 502. https://doi.org/10.3389/fpsyg.2015.00502

Giurgiu, M., Bussmann, J. B. J., Hill, H., Anedda, B., Kronenwett, M., Koch, E. D., Ebner-Priemer, U. W., & Reichert, M. (2020). Validating Accelerometers for the Assessment of Body Position and Sedentary Behavior. *Journal for the Measurement of Physical Behaviour*, *3*(3), 253–263. https://doi.org/10.1123/JMPB.2019-0068

Giurgiu, M., Ebner-Priemer, U. W., & Dumuid, D. (2022). Compositional insights on the association between physical activity and sedentary behavior on momentary mood in daily life. *Psychology of Sport and Exercise*, *58*, 102102. https://doi.org/10.1016/j.psychsport.2021.102102

Giurgiu, M., Koch, E. D., Ottenbacher, J., Plotnikoff, R. C., Ebner-Priemer, U. W., & Reichert, M. (2019). Sedentary behavior in everyday life relates negatively to mood: An ambulatory assessment study. *Scandinavian Journal of Medicine & Science in Sports*, *29*(9), 1340–1351. https://doi.org/10.1111/SMS.13448

Hallgren, M., Nguyen, T. T. D., Owen, N., Vancampfort, D., Smith, L., Dunstan, D. W., Andersson, G., Wallin, P., & Ekblom-Bak, E. (2020). Associations of interruptions to leisure-time sedentary behaviour with symptoms of depression and anxiety. *Translational Psychiatry*, *10*(1), 1–8. https://doi.org/10.1038/s41398-020-0810-1

Herbert, B. M., Ulbrich, P., & Schandry, R. (2007). Interoceptive sensitivity and physical effort: Implications for the self-control of physical load in everyday life. *Psychophysiology*, *44*(2), 194–202. https://doi.org/10.1111/j.1469-8986.2007.00493.x

Heron, K. E., & Smyth, J. M. (2010). Ecological momentary interventions: Incorporating mobile technology into psychosocial and health behaviour treatments. *British Journal of Health Psychology*, *15*(1), 1–39. https://doi.org/10.1348/135910709X466063

Hoffman, Lesa. (2014). *Longitudinal analysis : modeling within-person fluctuation and change*. Routledge. https://www.routledge.com/Longitudinal-Analysis-Modeling-Within-Person-Fluctuation-and-Change/Hoffman/p/book/9780415876025

Höller, I., Stenzel, J.-S., Rath, D., & Forkmann, T. (2021). Listen to Your Heart-Ecological Momentary Assessment of Interoceptive Accuracy, Awareness and Sensibility: A Pilot Study. *Public Health*, *18*, 4893. https://doi.org/10.3390/ijerph18094893

Jones, G. E., & Hollandsworth, J. G. (1981). Heart Rate Discrimination Before and After Exercise-Induced Augmented Cardiac Activity. *Psychophysiology*, *18*(3), 252–257. https://doi.org/10.1111/j.1469-8986.1981.tb03029.x

Kanning, M., Niermann, C., Ebner-Primer, U., & Giurgiu, M. (2021). The context matters - not all prolonged sitting bouts are equally related to momentary affective states: an ambulatory assessment with sedentary-triggered E-diaries. *International Journal of Behavioral Nutrition and Physical Activity*, *18*(1), 1–12. https://doi.org/10.1186/S12966-021-01170-3/TABLES/3

Khalsa, S. S., Adolphs, R., Cameron, O. G., Critchley, H. D., Davenport, P. W., Feinstein, J. S., Feusner, J. D., Garfinkel, S. N., Lane, R. D., Mehling, W. E., Meuret, A. E., Nemeroff, C. B., Oppenheimer, S., Petzschner, F. H., Pollatos, O., Rhudy, J. L., Schramm, L. P., Simmons, W. K., Stein, M. B., … Zucker, N. (2018). Interoception and Mental Health: A Roadmap. *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging*, *3*(6), 501–513. https://doi.org/10.1016/j.bpsc.2017.12.004

Kim, J., Kikuchi, H., & Yamamoto, Y. (2013). Systematic comparison between ecological momentary assessment and day reconstruction method for fatigue and mood states in healthy adults. *British Journal of Health Psychology*, *18*(1), 155–167. https://doi.org/10.1111/BJHP.12000

Köteles, F., Éliás, I., Szabolcs, Z., Körmendi, J., Ferentzi, E., & Szemerszky, R. (2020). Accuracy of reproduction of physical training load is not associated with resting heartbeat perception in healthy individuals. *Biological Psychology*, *150*(April 2019), 107831. https://doi.org/10.1016/j.biopsycho.2019.107831

Kwon, M., Jung, Y. C., Lee, D., & Lee, J. (2022). Altered resting-state functional connectivity of the dorsal anterior cingulate cortex with intrinsic brain networks in male problematic smartphone users. *Frontiers in Psychiatry*, *13*, 2272. https://doi.org/10.3389/FPSYT.2022.1008557/BIBTEX

Liao, Y., Shonkoff, E. T., & Dunton, G. F. (2015). The Acute Relationships Between Affect, Physical Feeling States, and Physical Activity in Daily Life: A Review of Current Evidence. *Frontiers in Psychology*, *6*(DEC). https://doi.org/10.3389/FPSYG.2015.01975

Livingston, G., Huntley, J., Sommerlad, A., Ames, D., Ballard, C., Banerjee, S., Brayne, C., Burns, A., Cohen-Mansfield, J., Cooper, C., Costafreda, S. G., Dias, A., Fox, N., Gitlin, L. N., Howard, R., Kales, H. C., Kivimäki, M., Larson, E. B., Ogunniyi, A., … Mukadam, N. (2020). Dementia prevention, intervention, and care: 2020 report of the Lancet Commission. *The Lancet*, *396*(10248), 413–446. https://doi.org/10.1016/S0140-6736(20)30367-6/ATTACHMENT/CEE43A30-904B-4A45-A4E5-AFE48804398D/MMC1.PDF

Lüdecke, D. (2018). ggeffects: Tidy Data Frames of Marginal Effects from Regression Models. *Journal of Open Source Software*, *3*(26), 772. https://doi.org/10.21105/JOSS.00772

Lüdecke, D., Ben-Shachar, M. S., Patil, I., Waggoner, P., & Makowski, D. (2021). performance: An R Package for Assessment, Comparison and Testing of Statistical Models. *Journal of Open Source Software*, *6*(60), 3139. https://doi.org/10.21105/JOSS.03139

Marshall, A. C., Gentsch, A., & Schütz-Bosbach, S. (2018). The interaction between interoceptive and action states within a framework of predictive coding. *Frontiers in Psychology*, *9*(FEB), 180. https://doi.org/10.3389/fpsyg.2018.00180

Marshall, A. C., Gentsch-Ebrahimzadeh, A., & Schütz-Bosbach, S. (2022). From the inside out: Interoceptive feedback facilitates the integration of visceral signals for efficient sensory processing. *NeuroImage*, *251*, 119011. https://doi.org/10.1016/J.NEUROIMAGE.2022.119011

McMorris, T., Barwood, M., & Corbett, J. (2018). Central fatigue theory and endurance exercise: Toward an interoceptive model. *Neuroscience and Biobehavioral Reviews*, *93*, 93–107. https://doi.org/10.1016/j.neubiorev.2018.03.024

Mehling, W. (2016). Differentiating attention styles and regulatory aspects of self-reported interoceptive sensibility. In *Philosophical Transactions of the Royal Society B: Biological Sciences* (Vol. 371, Issue 1708). https://doi.org/10.1098/rstb.2016.0013

Mölbert, S. C., Sauer, H., Dammann, D., Zipfel, S., Teufel, M., Junne, F., Enck, P., Giel, K. E., & Mack, I. (2016). Multimodal body representation of obese children and adolescents before and after weight-Loss treatment in comparison to normal-Weight children. *PLoS ONE*, *11*(11), 1–14. https://doi.org/10.1371/journal.pone.0166826

Montgomery, W. A., Jones, G. E., & Hollandsworth, J. G. (1984). The effects of physical fitness and exercise on cardiac awareness. *Biological Psychology*, *18*(1), 11–22. https://doi.org/10.1016/0301-0511(84)90022-X

Montoye, A., Pivarnik, J., Mudd, L., Biswas, S., & Pfeiffer, K. (2016). Validation and Comparison of Accelerometers Worn on the Hip, Thigh, and Wrists for Measuring Physical Activity and Sedentary Behavior. *AIMS Public Health*, *3*(2), 298–312. https://doi.org/10.3934/PUBLICHEALTH.2016.2.298

Murphy, J., Brewer, R., Plans, D., Khalsa, S. S., Catmur, C., & Bird, G. (2020). Testing the independence of self-reported interoceptive accuracy and attention. *Quarterly Journal of Experimental Psychology (2006)*, *73*(1), 115–133. https://doi.org/10.1177/1747021819879826

Nord, C. L., & Garfinkel, S. N. (2022). Interoceptive pathways to understand and treat mental health conditions. *Trends in Cognitive Sciences*, *26*(6), 499–513. https://doi.org/10.1016/j.tics.2022.03.004

Oldroyd, K., Pasupathi, M., & Wainryb, C. (2019). Social Antecedents to the Development of Interoception: Attachment Related Processes Are Associated With Interoception. *Frontiers in Psychology*, *10*, 712. https://doi.org/10.3389/fpsyg.2019.00712

Paik, S.-H., Park, C., Kim, J.-Y., Chun, J.-W., Choi, J.-S., & Kim, D.-J. (2019). Prolonged Bedtime Smartphone Use is Associated With Altered Resting-State Functional Connectivity of the Insula in Adult Smartphone Users. *Frontiers in Psychiatry*, *0*, 516. https://doi.org/10.3389/FPSYT.2019.00516

Palmer, C. E., & Tsakiris, M. (2018). Going at the heart of social cognition: is there a role for interoception in self-other distinction? *Current Opinion in Psychology*, *24*, 21–26. https://doi.org/10.1016/j.copsyc.2018.04.008

Pennebaker, J. W., & Lightner, J. M. (1980). Competition of internal and external information in an exercise setting. *Journal of Personality and Social Psychology*, *39*(1), 165–174. http://www.ncbi.nlm.nih.gov/pubmed/7411392

Perakakis, P., Luque-Casado, A., Ciria, L. F., Ivanov, P. Ch., & Sanabria, D. (2017). Neural Responses to Heartbeats of Physically Trained and Sedentary Young Adults. *BioRxiv*, 156802. https://doi.org/10.1101/156802

Pollatos, O., & Schandry, R. (2008). Emotional processing and emotional memory are modulated by interoceptive awareness. *Cognition and Emotion*, *22*(2), 272–287. https://doi.org/10.1080/02699930701357535

Puk, T. (2021). Intree: embodied experience in a flat screen world. *Journal of Outdoor and Environmental Education*, *24*(1), 55–69. https://doi.org/10.1007/S42322-020-00073-4/METRICS

Quadt, L., Garfinkel, S. N., Mulcahy, J. S., Larsson, D. E., Silva, M., Jones, A.-M., Strauss, C., & Critchley, H. D. (2021). Interoceptive training to target anxiety in autistic adults (ADIE): A single-center, superiority randomized controlled trial. *EClinicalMedicine*, *39*, 101042. https://doi.org/10.1016/j.eclinm.2021.101042

Quigley, K. S., Kanoski, S., Grill, W. M., Barrett, L. F., & Tsakiris, M. (2021). Functions of Interoception: From Energy Regulation to Experience of the Self. *Trends in Neurosciences*, *44*(1), 29–38. https://doi.org/10.1016/j.tins.2020.09.008

Radespiel-Tröger, M., Rauh, R., Mahlke, C., Gottschalk, T., & Mück-Weymann, M. (2003). Agreement of two different methods for measurement of heart rate variability. *Clinical Autonomic Research*, *13*(2), 99–102. https://doi.org/10.1007/s10286-003-0085-7

Razon, S., Basevitch, I., Filho, E., Land, W., Thompson, B., Biermann, M., & Tenenbaum, G. (2010). Associative and Dissociative Imagery Effects on Perceived Exertion and Task Duration. *Journal of Imagery Research in Sport and Physical Activity*, *5*(1). https://doi.org/10.2202/1932-0191.1044

Razon, S., Mandler, K., Arsal, G., Tokac, U., & Tenenbaum, G. (2014). Effects of imagery on effort perception and cycling endurance. *Journal of Imagery Research in Sport and Physical Activity*, *9*(1), 23–38. https://doi.org/10.1515/jirspa-2013-0011

Reichert, M., Giurgiu, M., Koch, E. D., Wieland, L. M., Lautenbach, S., Neubauer, A. B., von Haaren-Mack, B., Schilling, R., Timm, I., Notthoff, N., Marzi, I., Hill, H., Brüßler, S., Eckert, T., Fiedler, J., Burchartz, A., Anedda, B., Wunsch, K., Gerber, M., … Liao, Y. (2020). Ambulatory Assessment for Physical Activity Research: State of the Science, Best Practices and Future Directions. *Psychology of Sport and Exercise*, *50*. https://doi.org/10.1016/J.PSYCHSPORT.2020.101742

Reichert, M., Tost, H., Reinhard, I., Schlotz, W., Zipf, A., Salize, H. J., Meyer-Lindenberg, A., & Ebner-Priemer, U. W. (2017). Exercise versus nonexercise activity: E-diaries unravel distinct effects on mood. *Medicine and Science in Sports and Exercise*, *49*(4), 763–773. https://doi.org/10.1249/MSS.0000000000001149

Robinson, E., Foote, G., Smith, J., Higgs, S., & Jones, A. (2021). Interoception and obesity: a systematic review and meta-analysis of the relationship between interoception and BMI. *International Journal of Obesity 2021 45:12*, *45*(12), 2515–2526. https://doi.org/10.1038/s41366-021-00950-y

Rosseel, Y et al. (2023). Package “lavaan”. Latent Variable Analysis.

Schandry, R. (1981). Heart Beat Perception and Emotional Experience. *Psychophysiology*, *18*(4), 483–488. https://doi.org/10.1111/j.1469-8986.1981.tb02486.x

Schillings, C., Schultchen, D., & Pollatos, O. (2021). Effects of a Single Yoga Session on Cardiac Interoceptive Accuracy and Emotional Experience. *Brain Sciences*, *11*(12). https://doi.org/10.3390/brainsci11121572

Schulz, A., & Vögele, C. (2015). Interoception and stress. *Frontiers in Psychology*, *6*(July), 1–23. https://doi.org/10.3389/fpsyg.2015.00993

Schwerdtfeger, A., Eberhardt, R., Chmitorz, A., & Schaller, E. (2010). Momentary affect predicts bodily movement in daily life: an ambulatory monitoring study. *Journal of Sport & Exercise Psychology*, *32*(5), 674–693. https://doi.org/10.1123/JSEP.32.5.674

Stamatakis, E., Koster, A., Hamer, M., Rangul, V., Lee, I. M., Bauman, A. E., Atkin, A. J., Aadahl, M., Matthews, C. E., Mork, P. J., Askie, L., Cistulli, P., Granat, M., Palm, P., Crowley, P. J., Stevens, M., Gupta, N., Pulakka, A., Stenholm, S., … Holtermann, A. (2019). Emerging collaborative research platforms for the next generation of physical activity, sleep and exercise medicine guidelines: the Prospective Physical Activity, Sitting, and Sleep consortium (ProPASS). *British Journal of Sports Medicine*, *54*(8), 435–437. https://doi.org/10.1136/BJSPORTS-2019-100786

Suksasilp, C., & Garfinkel, S. N. (2022). Towards a comprehensive assessment of interoception in a multi-dimensional framework. *Biological Psychology*, *168*, 108262. https://doi.org/10.1016/J.BIOPSYCHO.2022.108262

Tanay, G., & Bernstein, A. (2013). State mindfulness scale (SMS): Development and initial validation. *Psychological Assessment*, *25*(4), 1286–1299. https://doi.org/10.1037/a0034044

Terasawa, Y., Fukushima, H., & Umeda, S. (2013). How does interoceptive awareness interact with the subjective experience of emotion? An fMRI Study. *Human Brain Mapping*, *34*(3), 598–612. https://doi.org/10.1002/hbm.21458

Toner, J., Montero, B. G., & Moran, A. (2016). Reflective and prereflective bodily awareness in skilled action. *Psychology of Consciousness: Theory, Research, and Practice*, *3*(4), 303–315. https://doi.org/10.1037/CNS0000090

Tremblay, M. S., Aubert, S., Barnes, J. D., Saunders, T. J., Carson, V., Latimer-Cheung, A. E., Chastin, S. F. M., Altenburg, T. M., Chinapaw, M. J. M., Aminian, S., Arundell, L., Hinkley, T., Hnatiuk, J., Atkin, A. J., Belanger, K., Chaput, J. P., Gunnell, K., Larouche, R., Manyanga, T., … Wondergem, R. (2017). Sedentary Behavior Research Network (SBRN) - Terminology Consensus Project process and outcome. *International Journal of Behavioral Nutrition and Physical Activity*, *14*(1), 1–17. https://doi.org/10.1186/S12966-017-0525-8/FIGURES/3

Trevisan, D. A., Mehling, W. E., & McPartland, J. C. (2021). Adaptive and Maladaptive Bodily Awareness: Distinguishing Interoceptive Sensibility and Interoceptive Attention from Anxiety-Induced Somatization in Autism and Alexithymia. *Autism Research : Official Journal of the International Society for Autism Research*, *14*(2), 240–247. https://doi.org/10.1002/AUR.2458

Trull, T. J., & Ebner-Priemer, U. (2013). Ambulatory assessment. *Annual Review of Clinical Psychology*, *9*, 151–176. https://doi.org/10.1146/ANNUREV-CLINPSY-050212-185510

Tsakiris, M., & Critchley, H. (2016). Interoception beyond homeostasis: affect, cognition and mental health. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *371*(1708). https://doi.org/10.1098/rstb.2016.0002

Wallman-Jones, A., Palser, E. R., Benzing, V., & Schmidt, M. (2022). Acute physical-activity related increases in interoceptive ability are not enhanced with simultaneous interoceptive attention. *Scientific Reports*, *12*(1), 15054. https://doi.org/10.1038/s41598-022-19235-z

Wallman-Jones, A., Perakakis, P., Tsakiris, M., & Schmidt, M. (2021). Physical activity and interoceptive processing: Theoretical considerations for future research. *International Journal of Psychophysiology*, *166*, 38–49. https://doi.org/10.1016/j.ijpsycho.2021.05.002

Wang, X., Wu, Q., Egan, L., Gu, X., Liu, P., Gu, H., Yang, Y., Luo, J., Wu, Y., Gao, Z., & Fan, J. (2019). Anterior insular cortex plays a critical role in interoceptive attention. *ELife*, *8*. https://doi.org/10.7554/eLife.42265

Weng, H. Y., Feldman, J. L., Leggio, L., Napadow, V., Park, J., & Price, C. J. (2021). Interventions and Manipulations of Interoception. In *Trends in Neurosciences* (Vol. 44, Issue 1, pp. 52–62). Elsevier Ltd. https://doi.org/10.1016/j.tins.2020.09.010

Williamson, J. W., McColl, R., Mathews, D., Ginsburg, M., & Mitchell, J. H. (1999). Activation of the insular cortex is affected by the intensity of exercise. *Journal of Applied Physiology*, *87*(3), 1213–1219. https://doi.org/10.1152/jappl.1999.87.3.1213

Williamson, J. W., Nobrega, A. C., McColl, R., Mathews, D., Winchester, P., Friberg, L., & Mitchell, J. H. (1997). Activation of the insular cortex during dynamic exercise in humans. *The Journal of Physiology*, *503 (Pt 2)*, 277–283. http://www.ncbi.nlm.nih.gov/pubmed/9306272

Wittkamp, M. F., Bertsch, K., Vögele, C., & Schulz, A. (2018). A latent state-trait analysis of interoceptive accuracy. *Psychophysiology*, *55*(6), e13055. https://doi.org/10.1111/psyp.13055

Zarza, J. A., Sanabria, D., & Perakakis, P. (2019). Can increased interoception explain exercise-induced benefits on brain function and cognitive performance? *Experimental Psychology*, 1–16.

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Highlights

- Physical activity influences self-reported interoception in daily life
- Baseline interoceptive accuracy influences the direction of effects
- Momentary sedentary behavior displays contrasting relationships
- Activity type matters – supports both attentional and physiological mechanisms