Associations between physical activity, sedentary behaviour, and stress using ecological momentary assessment

Wright, Laura; Williams, Sarah; Veldhuijzen van Zanten, Jet

DOI:
10.1016/j.mhpa.2023.100518

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

Citation for published version (Harvard):
Wright, L, Williams, S & Veldhuijzen van Zanten, J 2023, 'Associations between physical activity, sedentary behaviour, and stress using ecological momentary assessment: A scoping review', *Mental Health and Physical Activity*, vol. 24, 100518. https://doi.org/10.1016/j.mhpa.2023.100518

Mental Health and Physical Activity 24 (2023) 100518

Contents lists available at ScienceDirect

Mental Health and Physical Activity

journal homepage: www.elsevier.com/locate/menpa

Associations between physical activity, sedentary behaviour, and stress using ecological momentary assessment: A scoping review

Laura J. Wright *, Sarah E. Williams, Jet J.C.S. Veldhuijzen van Zanten

School of Sport, Exercise and Rehabilitation Sciences, College of Life and Environmental Sciences, University of Birmingham, United Kingdom

ARTICLE INFO

Keywords:
Exercise
Physical inactivity
Mental health
Distress
Experience sampling

ABSTRACT

Background: Physical activity (PA) and sedentary behaviour (SB) have previously been seen to be associated with stress. However, observed associations have been inconsistent in direction. Research tends to examine associations at one given time point without considering how these constructs change over time. Ecological momentary assessment (EMA) is one potential method to examine how the relationships between PA or SB and stress change over time taking variations in PA/SB and stress within and between days into consideration.
Objectives: This scoping review aimed to examine the concurrent and prospective relationships between PA/SB and stress and vice versa, using EMA methodology.
Design: 5 online data bases were used to search for EMA research that included measures of PA/SB and stress, where a PA/SB-stress relationship was examined. Searches were run up until February 2022. Papers were assessed for eligibility for inclusion, with 33 papers found to fit the required criteria.
Results: 28 of the included studies focussed on PA, with 2 focussing on SB, and 3 on both PA and SB. Studies used a mix of between- and within-person analyses as well as examining associations over concurrent and/or prospective time frames. Taking into consideration analyses and time frame, results were inconclusive, with approximately half of the studies finding no association. Overall findings appear to be mixed. However, some evidence on a within-person level suggests that stress is associated with subsequent lower levels of PA, as well as PA being associated with lower levels of subsequent stress.
Conclusions: Future research should investigate the impact of the way stress is quantified, different intensities of PA and the context of both PA and SB in order to get a better understanding of the associations between PA/SB and stress. In addition, more detailed studies are needed to explore personal and contextual factors that could influence these associations is warranted.

1. Introduction

Stress is highly prevalent in society, with a survey suggesting that 74% of UK adults felt so stressed that they were unable to cope (Mental Health Foundation, 2018). Stress can be defined as the response to a situation when the demands of that situation exceed an individuals perceived ability to cope (Fink, 2016). It can include life events or person centred stresses (Segerstrom & O'Connor, 2012). Although stress can at times be beneficial, such as improving performance, effort, and proactive coping (Jamieson et al., 2018), there is also ample evidence that both acute and chronic stress can have a negative impact on physical and mental wellbeing, such as cardiovascular disease (Kivimäki & Steptoe, 2018; Song et al., 2019) and depression (Hammen et al., 2009; Parrish et al., 2011). Therefore, it is important to find ways to reduce the negative implications of stress in order to sustain good mental and physical health and wellbeing.

Physical activity (PA) has long been promoted for the promotion of positive physical health outcomes such as the prevention of cardiovascular disease and improved outcomes in type 2 diabetes mellitus (Anderson & Durstine, 2019). PA has also been seen to be associated with improved mental health, such as reduced anxiety (Wipfli et al., 2008) and depression (Gianfredi et al., 2020). Sedentary behaviour (SB) has its own unique health consequences independent of PA. For example, even in those who are physically active, increased sitting time is associated with an increased risk for poor health (Ekelund et al., 2019). Both PA and SB have been suggested as health behaviours

* Corresponding author. School of Sport, Exercise and Rehabilitation Sciences, College of Life and Environmental Sciences, University of Birmingham, B15 2TT, United Kingdom.
E-mail address: laurajwright1994@gmail.com (L.J. Wright).

https://doi.org/10.1016/j.mhpa.2023.100518
Received 18 October 2022; Received in revised form 30 March 2023; Accepted 27 April 2023
Available online 28 April 2023

associated with stress. Reviews have reported stress as a predictor of PA, but also PA as a predictor of stress (Mikkelsen et al., 2017; Stults-Kolehmainen & Sinha, 2014), potentially suggesting that the PA-stress association is bi-directional in nature. A review into the relationship between SB and stress resulted in equivocal findings, with positive, negative and no associations being reported, and it was concluded that there is currently insufficient evidence to comment on the association between overall SB and stress (Teychenne et al., 2019). Therefore, the varied and inconsistent relationships between PA/SB and stress require more investigation.

One possible reason for the equivocal results found for the PA/SB and stress relationship is the way that the studies are conducted. In the Stults-Kolehmainen and Sinha (2014) review approximately two thirds of the studies included examined a single time point. Of these papers examining stress and PA at a single time point, two thirds of papers found higher stress was associated with lower PA. However, within the same review, when examining if stress could predict PA from 2 weeks to multiple years in the future, Stults-Kolehmainen and Sinha (2014) found equivocal results. When examining SB, the Teychenne et al. (2019) review predominately examined single time point studies but in contrast to Stults-Kolehmainen and Sinha (2014) found equivocal results. Additionally, within the Stults-Kolehmainen and Sinha (2014) review, single time point studies and prospective studies returned different associations. As PA/SB and stress fluctuate between and within days (Shang et al., 2018; von der Embse & Mankin, 2021) this is perhaps to be expected, but is largely overlooked when studies ask participants to report their PA/SB and stress as general levels over several days or weeks. Therefore, it is important to use a methodology that allows for the examination of these relationships taken into consideration fluctuations within and between days, and not just at a single time point, to gain a more comprehensive overview of the existence and direction of a PA/SB-stress relationship.

One methodology that could be used to examine the PA/SB-stress relationship over time is Ecological Momentary Assessment (EMA). EMA is a method which uses repeated sampling of participant behaviour, feelings, and experiences in real time while participants go about their normal lives (Shiffman et al., 2008). Capturing data in participants' free-living environment over several days allows researchers to examine how fluctuations in PA/SB, both between and within days, are related to fluctuations in stress over the same time period (Dunton, 2017; Shiffman et al., 2008). Collecting data in this way allows for the separation of between-person (deviation from average group level) and within-person (deviation from individuals own average) associations. In other words, it enables researchers to explore if the associations are mainly driven by variations in general levels of PA/SB/stress (i.e., deviation from average group level) or temporal variations in PA/SB/stress at an individual level (i.e., deviation from individual own average) (Curran & Bauer, 2011; Dunton, 2017). Using EMA also provides a good opportunity to assess both concurrent and prospective associations. Concurrent associations refer to relationships between PA/SB and stress occurring at the same time such as overall day levels. Prospective associations refer to how PA/SB at one time point is associated with stress at a subsequent time point. For example, prospective associations could explore the associations between PA in the morning with stress that afternoon. Being able to examine between and within-person associations between PA/SB and stress, as well as simultaneously examining the concurrent and prospective associations would allow for a more comprehensive examination of the existence and direction of potential PA/SB-stress relationships.

While EMA has previously been used to explore variations within and between days in stress, as well as objective and subjective PA/SB, the extent of this research is not known. Little is also known to what extent EMA has been used to examine the PA/SB and stress relationship when both variables have been measured using EMA assessments or continuous monitoring, or what the outcomes of this research are. A scoping review would be beneficial as it would allowed for the examination of what evidence is already available relating to the area of interest (PA/SB and stress relationships using the EMA methodology), as well as providing an overview of which research designs have been used to explore these associations, and how the relevant concepts (PA/SB and stress) have been examined. In addition a scoping review can be used to highlight any potential gaps in this area that need to be investigated in order to progress the field (Munn et al., 2018; Peters et al., 2015). Given the increased availability of wearable technology to track behaviour in real-life setting, it is timely to provide an overview of the existing literature. For these reasons, a scoping review was chosen as an appropriate method to examine the literature investigating PA/SB and stress relationships using EMA methodology.

1.1. Aims and research questions

The current scoping review aimed to examine the research currently available that utilises EMA to investigate the relationships between PA/SB and stress. While stress can be conceptualised in different ways, in this review, psychological stress is conceptualised as reported perceptions, feelings and experiences of psychological stress. Key characteristics of EMA methodology are the ability to examine between and within-person association, as well as concurrent and prospective associations. Therefore, this scoping review aimed to identify studies that examine whether PA/SB is associated with stress using EMA methodology and address the following research questions:

What are the concurrent associations between PA/SB and stress and vice versa in studies using EMA methodologies?
What are the prospective associations between PA/SB and stress and vice versa in studies using EMA methodologies?

2. Methods

The review was guided by the PRISMA scoping review extension checklist (Tricco et al., 2018). This checklist, which specifies where/how the review complies with these guidelines is included as supplementary data. The scoping review framework presented by Peters et al. (2015) was also used to guide the entire review process, and this is reflected in the reporting of the results (e.g., flow chart, which data to report and how to report the data).

2.1. Eligibility criteria

Papers were eligible for inclusion if they met the following criteria: used an ecological momentary assessment methodology of any length and contained a measure of stress. Papers also had to include a measure of PA OR SB. Study participants could be from any age group. Articles could be from any date up until the end of February 2022, published in English. Papers were excluded from the review based on the following exclusion criteria: the participants in the study were from a current clinical population as it was deemed that clinical factors may impact on PA levels, a relationship between PA/SB and stress was not examined, PA/SB and stress were only presented as a baseline value, conference abstract only available, or studies if they were presented without results (see Table 1 for further guidance on inclusion criteria).

2.2. Information sources and search strategy

Searches were conducted using Medline, EMBASE, PsycInfo, PubMed and the Cochrane Library. Searches were run up until February 2022. The search terms used comprised three main groups: ecological momentary assessment terms, PA/SB terms and stress terms.

The search terms used were: "(ecological momentary assessment OR experience sampl* OR ambulatory assessment OR diary) AND (physical activity OR exercise OR walk* OR active OR movement OR sport OR sedentary* OR sitting OR television OR inactiv* OR physical inactivity)

Table 1
Inclusion criteria and guidance screening chart.

Criteria	Guidance
Ecological Momentary Assessment	Uses an ecological momentary assessment methodology of any length
Physical Activity OR Sedentary Behaviour Measure	Can be objective or subjective. Can be a continuous monitoring OR measured with EMA prompts. Must have at least one measurement (or have continuous measurement on each EMA day) Exclude if baseline measure only
Stress	Any measure of stress (e.g., perceived stress scale, daily hassles etc) Must be measured at least once per EMA day. Exclude if baseline measure only
Participants	Any age groups. Cannot be in a current clinical population (e.g., inpatient participants, current chemotherapy etc)
Physical Activity/Sedentary Behaviour and Stress Relationship	Must contain a measure of a relationship between PA/SB and stress (e.g., correlation, regression, multilevel modelling etc).
Full Paper Availability	Exclude if only conference abstract, no results available (e.g., feasibility studies)
English Language	Exclude if not available in English

AND (stress OR psychological stress OR mental stress OR everyday stress OR distress)." Truncations were used to encompass multiple word endings (e.g., sampl* would capture sample, sampling etc.).

2.3. Study screening, paper selection and data charting

Papers were downloaded into EndNote (X9.2) reference management software and duplicate articles removed. Titles and abstracts were then screened for eligibility using the screening guidance (Table 1) and any irrelevant papers excluded. All titles and abstracts were screened by author 1, with author 3 screening a randomly assigned sample (20% of papers). Any papers where disagreements about inclusion arose were screened in full. Full text articles were then read to establish final inclusion, using the same process. Any disagreements regarding inclusion were discussed by author 1 and author 3, referring back to the inclusion and exclusion criteria to reach consensus. The final total number of papers in the review was 33 and were agreed and read in full by authors 1 and 3 (see Fig. 1 for process chart, used in accordance with Peters et al. (2015) framework). Data was charted in table form in Microsoft Excel (version 2010), with separate Tables for concurrent relationships (Table 2) and prospective relationships (Table 3) using suggestions from the Peters et al. (2015) framework for guidance on data charting. Data charted included participant characteristics, EMA duration and assessment characteristics, PA/SB measure, stress measure, analysis used and whether relationships examined were within or between-person.

2.4. Categorising the results

Results were presented in tabular and descriptive format as suggested in the scoping review framework proposed by Peters et al. (2015), with separate Tables for studies reporting on concurrent and prospective associations. Within these broader categories, papers were further split into those that use a within-person or between-person analysis and whether the paper examined the relationship between PA/SB and stress, or stress and PA/SB. Between-person analyses explore associations in general levels of PA/SB/stress based on an overall average of these outcomes per participant. Within-person analyses explore associations in temporal variations in PA/SB/stress at an individual level. A range of statistical analyses were used to explore between-person and within-person analyses. Correlations and regression analyses can be used to explore between-person associations. Multilevel analyses are more commonly used to explore both between- and within-person associations. To examine both research questions, studies were also categorised as either "concurrent" or "prospective". Concurrent associations were deemed to be any PA and stress measurements taken at the same time and relating to the same time period. For example, looking at associations between daily averages of PA and stress is concurrent. Prospective analyses involved the assessment of associations between an assessment of an outcome (PA/SB or stress) at a specified time and the assessment of the other outcome (stress or PA/SB) at a later time. For example, the association between PA measured on the hour, and stress measured as little as 15 min later, or longer periods such as stress measured in an evening and the associations with PA the following day. Studies using an 'N-of-1' design are reported separately. These studies assessed participants for up to 1 year and completed separate analyses per participant and then report the overall summary of these individual analyses.

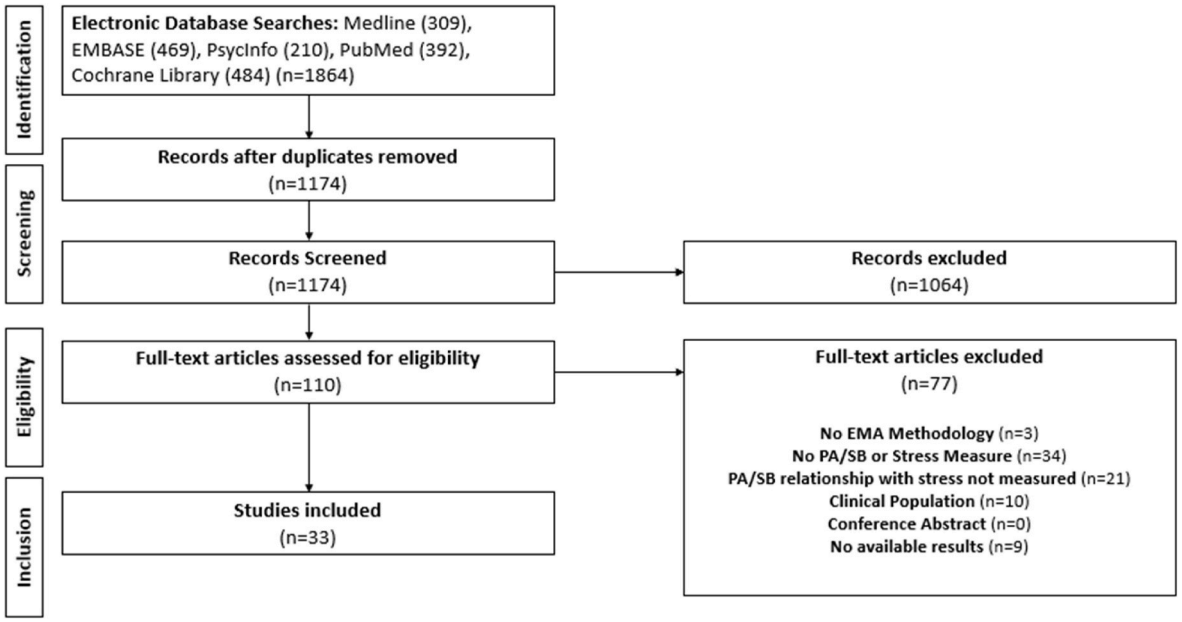

Fig. 1. Paper screening process for inclusion.

Table 2
Concurrent Associations between Physical activity/Sedentary Behaviour, and Stress.

Author	Participants, EMA Duration and Assessments	PA/SB Measure	Stress Measure	Analysis	PA/SB-Stress associations from Between–Person analysis	PA/SB-Stress associations from Within–Person analysis
Stress associations with Physical Activity/Sedentary Behaviour						
daSilva et al. (2021)	88 students (m = 21yrs) 56% female EMA Characteristics: mean duration: 67 days, 1 per day (randomly between 9am and 8pm).	Passive Mobile Sensoring: Total distance travelled (km) (Ddaily)	How stressed are you? (daily)	Two step multilevel vector autoregressive model.	Not analysed.	↑ Stress associated with ↓ movement.
Diaz et al. (2018)	79 adults (m = 32yrs), 57% female EMA Characteristics: 1 year, 4x daily (includes an end of the day assessment)	Activity Monitor (Fitbit): SB: total number of minutes per day where 0 steps and intensity classification of 0 took place.	Overall, how stressful was your day? Have you experienced any of the following (list of stressors e.g., traffic, other) (both end of day assessment) How stressed did you feel (just before assessment)?	Random coefficients linear regression models	Not analysed.	End of day stress not associated with sitting time. ↓ end of day stress associated with ↑ bouts (≥90 min) of SB.
Lin et al. (2021)	70 adults (m = 42yrs) 100% female EMA Characteristics: 7 days, 5x daily (7am–10am, 10am-1pm, 1pm–4pm, 4pm–7pm, 7pm–10pm)	Accelerometer: Daily minutes of MVPA and SB	Daily work hassles (last prompt of the day)	Bivariate fixed effect regression Logistic fixed effects regression.	Not analysed.	↑ Work hassles associated with ↑SB. No association between work hassles and MVPA
Määttänen et al. (2021)	44 adults (m = 25yrs) 77% female EMA Characteristics: 2 days active measurement (take own physiological measures), 1–3 days passive measurement (no involvement needed from participant to take measures) every 45 min (for both active measurement and passive measurement days)	Accelerometer: Movement (measured acceleration)	Has something stressful happened since the last report (Y/N)? How stressful was it? Were you in control of the situation?	Linear mixed models	Not analysed.	No association between stress and movement.
Pinto et al. (2020)	20 adults (m = 52yrs) Breast cancer survivors EMA Characteristics: 12 months, assessments at 0, 3, 6, 9, 12 months 7 days EMA each time 4x daily (8–11am, 11am-2pm, 2–5pm, 5–8pm)	Accelerometer: Activity Counts (SB) Self-Report: What are you doing now? (includes leisure and non-leisure SB)	How stressed do you feel right now?	Longitudinal regression models	Not analysed.	↑ stress associated with ↑ SB in univariate analysis only. Stress no longer associated with SB in multivariate model (affective valence, sadness, anxiety, stress, worry, fatigue, treatment, BMI, and ethnicity covariates).
Zenk et al. (2017)	97 adults (range - 25–65yrs) 100% female EMA Characteristics:7 days, 5x daily (7–10am, 10am-1pm, 1pm–4pm, 4pm–7pm, 7pm–10pm)	Accelerometer: Daily minutes of MVPA Daily hours of SB	Daily hassles (evening assessment)	Mixed multivariable linear regression models	Not analysed.	↑ Daily hassles associated with ↑ MVPA and ↓ levels of SB.
Gloster, A. H, et al. (2017)	108 students (m = 21yrs), 82% female EMA Characteristics: First 61 days: 1 assessment every 6 days (reflecting on day of assessment) Final 33 days: 1 assessment per day	Self-report: GLT – total daily activity score weighted by duration and intensity of activity.	Hassles (number in a 24-h period)	Correlations for each participant using multilevel structural equation models	Not analysed.	↑ Stress associated with ↑ PA.
Physical Activity/Sedentary Behaviour associations with Stress						
Igic et al. (2013)	39 adults (17+) (m = 32yrs), 51% female EMA Characteristics: 14 days, 1 per day (before bed)	Accelerometer: Time spent in PA (hours)	Daily social stressors (whole day)	Correlations per participants	Not analysed.	PA not associated with social stress.
Lindberg et al. (2018)	231 adults (m = 44yrs), 50% female EMA Characteristics: 3 days (consecutive workdays) Hourly during work hours	Accelerometer: Overall intensity of movement (including sitting, standing, walking).	How tense do you feel? (at the time of assessment)	Structural Equational Modelling	Pathway between PA and stress at work found to be non-significant.	Not analysed.
Anderson and Fowers (2020)	76 adults (m = 40yrs), 58% female EMA Characteristics: 14 days, 1 per day (released at 8pm	Self-report: GLT- total daily activity score weighted by duration	Kessler psychological distress scale (whole day)	Correlations and mixed multilevel modelling	↑ PA associated with ↓ psychological distress in correlation	No association between PA and distress in correlation analyses. No

(*continued on next page*)

Table 2 (*continued*)

Author	Participants, EMA Duration and Assessments	PA/SB Measure	Stress Measure	Analysis	PA/SB-Stress associations from Between–Person analysis	PA/SB-Stress associations from Within–Person analysis
		and intensity of activity.			analyses. In multilevel model, not associated	association in multilevel model.
Dalton (2020)	127 students (m = 19yrs), 75% female EMA Characteristics: 14 days, 1 per day (before bed)	Self-report: Minutes of MVPA	Daily stressors (whole day)	Hierarchical linear modelling.	Not analysed.	No association between PA and stress.
Li et al. (2019)	82 adults (m = 35yrs), 63% female EMA Characteristics: 7 days, 1 per day (evening)	Self-report: GLT - total daily activity score weighted by duration and intensity of activity.	Short form (4 item) PSS (whole day)	Between and within-person correlations	No association between PA and stress.	No association between PA and stress.
Strahler et al. (2020)	77 adults (m = 24yrs), ~49% female EMA Characteristics: 4 days, 5x daily (30 min after waking, 11am, 2pm, 6pm, 9pm)	Self-report: Total time (mins): Walked, Cycled, worked out, active in household (all activities summed)	I feel stressed. (at time of assessment, daily average calculated)	Two level hierarchical linear regression	Not analysed.	No association between PA and stress.
Zawadzki et al. (2015)	115 adults (m = 41yrs), 76% female EMA Characteristics: 3 days (Thursday-Saturday, 6x daily, randomly in 3hr intervals	Self-report: What were you doing at the time of the prompt? sports, exercise or recreation (yes or no).	How stressed are you? PSS (4 item) (at the time of assessment)	Mixed multilevel models.	Not analysed.	No association between PA and stress.
N-of 1 associations between Stress and Physical Activity/Sedentary Behaviour						
Comulada et al. (2018)	14 adults (m = 31yrs) 100% female EMA Characteristics: 6 months, 4x daily (only end of day assessment used in analyses)	Self-report: How many minutes of activity did you do today? (Sum of light, moderate and vigorous PA reports)	How stressful was your day overall? (end of day assessment)	Correlation	Not analysed.	↑ In stress associated with ↓ PA. (correlation only, not indicated if significant).

Note: EMA = Ecological Momentary Assessment PA = Physical Activity, SB = Sedentary Behaviour, MVPA = Moderate to Vigorous Physical Activity, LTPA = Leisure Time Physical Activity, LPA = Light Physical Activity, PSS = perceived stress scale, GLT = Godin Leisure Time Exercise Questionnaire.

3. Results

3.1. Overview

Tables 2 and 3 present the summaries of the studies reporting concurrent and prospective associations, respectively. Table 4 presents an overall summary of the associations. Most of the studies (n = 28) investigated PA, two studies focussed on SB (Diaz et al., 2018; Pinto et al., 2020) and three studies investigated both PA and SB (Jones et al., 2017; Lin et al., 2021; Zenk et al., 2017). Different measures of stress were used. Stress was most commonly (n = 17) measured relating to feelings of stress (e.g., how stressed do you feel?), but other studies (n = 10) used occurrence of hassles and stressors to assess stress level. PA was measured in 15 studies objectively (mainly accelerometers), 13 studies used self-report measures and 3 studies included both an accelerometer and self-report measures. All studies investigating SB used accelerometers to measure SB, with 1 study also including a self-report SB measure (Pinto et al., 2020). Studies varied with regards to sample size (ranging from 14 to 605), EMA sampling rate (ranging from 1 assessment per day to 1 assessment every 45 min), and number of days of measurement (ranging from 1 day to 1 year). Studies tended to have a higher percentage of female participants than males. Please see Tables 2 and 3 for more detailed information about the individual studies.

3.2. Physical activity

Concurrent Analysis – Between-Person: None of the studies included in the review explored concurrent between-person associations between stress and PA. None of the three studies which examined the concurrent between-person associations of PA predicting stress reported significant associations. A mix of accelerometer and self-report measures of PA were used alongside a range of stress measures (see Table 2). It is worth noting that Anderson and Fowers (2020) found higher levels of PA were associated with lower levels of stress, but when correcting for smoking, social interaction, socioeconomic status, and alcohol intake (Table 3), this association was no longer significant.

Concurrent Analyses – Within-Person: Five studies examined concurrent within-person associations of stress predicting PA in adults (n = 3) and students (n = 2). A mix of self-report and accelerometer measures of PA were used, with most studies using hassles/stressors as the stress measure. Two studies reported that high stress (measured as hassles) was associated with more overall daily PA (Gloster, A.H, et al., 2017; Zenk et al., 2017), and two studies reported no significant association between stress and PA (Lin et al., 2021; Määttänen et al., 2021). The only study that measured perceived stress, reported a negative association between stress and movement during the day (daSilva et al., 2021).

Six studies examined concurrent within-person associations of PA predicting stress in adults (n = 5) or students (n = 1), using self-report measures of PA and a range of stress measures, with the most common being feelings of stress (see Table 2). All studies reported no within-person associations between PA and stress (Anderson & Fowers, 2020; Dalton, 2020; I. Igic et al., 2013; Li et al., 2020; Strahler et al., 2020; Zawadzki et al., 2015).

Prospective Analyses – Between-Person: Six studies examined the prospective between-person associations of stress predicting subsequent PA in adults (n = 3), students (n = 1) or children (n = 2), using accelerometers to measure PA and feelings of stress or job demands as the stress-related outcome (see Table 3). Five studies reported no significant associations between stress and subsequent PA (Almeida et al., 2020; daSilva et al., 2021; Do et al., 2021; Määttänen et al., 2021; Naya et al., 2021). However, Almeida et al. (2020) (study 2) found higher stress was

Table 3
Prospective associations between Physical Activity/Sedentary Behaviour and Stress.

Author	Participants, EMA Duration and Assessments	PA/SB Measure	Stress Measure	Analysis	PA/SB-Stress associations from Between–Person analysis	PA/SB-Stress associations from Within–Person analysis
Associations between Stress and Physical Activity/Sedentary Behaviour						
Abdel Hadi et al. (2021)	199 adults (m = 36yrs) 76% female EMA Characteristics: 14 days, 3x daily	Accelerometer: Leisure time MVPA after work (mins)	Job demands and control (whole day, completed after work)	Multilevel Structural Equation analysis	Not analysed.	↑Job demands associated with ↓ after work LTPA.
Almeida et al. (2020) Study 1	Study 1: 115 adults, (m = 41yrs), 75% female EMA Characteristics: 3 days (Thursday-Saturday), 6x daily, random 2-h intervals	Study 1: Accelerometer Activity counts/minute (10-, 60- and 120-min post assessment)	Study 1: How stressed were you feeling? (since last prompt)	Mixed multilevel models	No association between perceived stress and PA.	No association between perceived stress and PA.
Almeida et al. (2020) Study 2	Study 2: 297 adults (m = 42yrs), 50% female EMA Characteristics: 2 days, every 45 min, fixed intervals	Study 2: Accelerometer Activity counts/minute (10-, 60- and 120-min post assessment)	Study 2: How stressed have you been? (since last prompt)	Multilevel models	↑ Perceived stress associated with ↑ PA in the subsequent 10, 60, and 120 min.	↑ Perceived stress associated with ↑ PA in the subsequent 10, 60, and 120 min.
Calderwood et al. (2021)	71 adults (m = 41yrs), 76% female EMA Characteristics: 5 days (Monday-Friday) 3x daily (6am–9am, 4pm–7pm, 9pm −12am)	Accelerometer: Total number of steps taken at work	Daily challenge and hindrance stressors on predicting day (afternoon survey)	Correlations	Not analysed.	No association between stress and PA during subsequent working day.
daSilva et al. (2021)	88 students (m = 21yrs) 56% female EMA Characteristics: mean duration: 67 days, 1 per day (randomly between 9am and 8pm).	Passive Mobile Sensoring: Total distance travelled (km) (daily)	How stressed are you? (daily)	Two step multilevel vector autoregressive model.	No association between stress and subsequent movement.	↑ Stress predicted ↓ movement the subsequent day. Stress did not predict movement 2 days later.
Do et al. (2021)	190 children (m = 10yrs) 53% female EMA Characteristics: 6 bursts of 7 days across 3 years 3x daily weekdays (3pm–8pm) 7x daily weekends (7am-8pm)	Accelerometer: MVPA 15, 30 and 60 min after each EMA prompt	Stress variable based on perceived stress, ability to manage things, and perceptions of things working out as planned (right now)	Multilevel structural equation modelling	No association between stress and subsequent MVPA in subsequent 15, 30, and 60 min.	↑ Stress associated with ↓MVPA in subsequent 15, 30, and 60 min.
Jones et al. (2017)	105 adults, (m = 40yrs) 72% female EMA Characteristics: 4 days (Saturday-Tuesday), 8x daily	Accelerometer: Total minutes of light, moderate, vigorous PA and SB.	How stressed were you? (right before the assessment)	Mixed multilevel models.	No associations between stress and subsequent SB, light PA, or MVPA.	↑ stress associated with ↓ SB in subsequent 15 min ↑ Stress associated with ↑ light PA in the subsequent 15 min. No association between stress and subsequent MVPA.
Lin et al. (2021)	70 adults (m = 42yrs) 100% female EMA Characteristics: 7 days, 5x daily (7am–10am, 10am-1pm, 1pm–4pm, 4pm–7pm, 7pm–10pm)	Accelerometer: Daily minutes of MVPA and SB	Daily work hassles (last prompt of the day)	Bivariate fixed effect regression Logistic fixed effects regression.	Not analysed.	No association between work hassles and SB No association between work hassles and MVPA.
Naya et al. (2020)	143 children (m = 10yrs), 44% female EMA Characteristics: 4 waves of data collection (6 months apart). In each wave, 2 weekend days of EMA data collected in morning.	Accelerometer: Daily minutes of moderate to vigorous PA.	Stress variable based on perceived stress, ability to manage things, and perceptions of things working out as planned (right now)	Mixed multilevel models.	No association between stress and MVPA.	↑ Stress in morning associated with ↓ MVPA during the day.
Pinto et al. (2020)	20 adults (m = 52yrs) Breast cancer survivors EMA Characteristics: 12 months, assessments at 0, 3, 6, 9, 12 months 7 days EMA each time 4x daily (8–11am, 11am-2pm, 2–5pm, 5–8pm)	Accelerometer: Activity Counts (SB) Self-Report: What are you doing now? (includes leisure and non-leisure SB)	How stressed do you feel right now?	Longitudinal mixed effects model Cross-lagged models.	Not analysed.	Stress not associated with SB in subsequent 3 h
Schultchen et al. (2019)	51 students (m = 24yrs), 80% female EMA Characteristics: 7 days 6x daily (9am, 11:30, 2pm, 4:30pm, 7pm, 9:30pm)	Accelerometer: Time in minutes Self-Report: How many minutes have you been physically active since the last	Perceived stress (2 items PSS) "Do you feel that you can cope with things" "Do you feel you're on top of things", and do you feel	Hierarchical linear models	Not analysed.	↑ Stress associated with ↓ PA in subsequent 2.5 h.

(*continued on next page*)

Table 3 (*continued*)

Author	Participants, EMA Duration and Assessments	PA/SB Measure	Stress Measure	Analysis	PA/SB-Stress associations from Between–Person analysis	PA/SB-Stress associations from Within–Person analysis
		signal (sweated or out of breath)	nervous/stressed (at time of assessment)			
Anderson and Fowers (2020)	76 adults (m = 40yrs), 58% female EMA Characteristics: 14 days, 1 per day (released at 8pm)	Self-report: GLT- total daily activity score weighted by duration and intensity of activity.	Kessler psychological distress scale (whole day)	Correlations and mixed multilevel modelling	Not analysed.	No association between PA and distress the subsequent day.
Nagel et al. (2015)	120 adults (m = 39yrs), 51% female EMA Characteristics: 5 days (Monday-Friday) 2x daily (after work, before bed)	Self-report: How many minutes exercised after work?	Job stressors (whole day)	Multilevel modelling	Not analysed.	No association between job stressors and exercise
Payne et al. (2010)	41 adults (no m age reported) 45% female EMA Characteristics: 14 days, 1 per day (~6pm)	Self-report: Sum (hours) of all exercise. For analysis, exercise dichotomised into exercise and non-exercise days.	Job demands (whole day)	Multilevel modelling	Not analysed.	No association between job demands and likelihood to exercise the subsequent day.
Sala et al. (2017)	129 students (m = 20yrs), 100% female EMA Characteristics: 7 days, 4x daily (1 per 3-h block)	Self-report: How long did you exercise since your last check in?	DASS- stress subscale (at the time of assessment)	Generalised linear mixed model	Not analysed.	No association between stress and PA in subsequent 3 h.
Associations between Physical Activity and Stress/Sedentary Behaviour						
Abdel Hadi et al. (2021)	199 adults (m = 36yrs) 76% female EMA Characteristics: 14 days, 3x daily	Accelerometer: Leisure time MVPA (mins)	How stressed do you feel at the moment? (completed at bedtime)	Multilevel structural equation analysis	Not analysed.	↑LTPA after work associated with ↓ evening stress.
daSilva et al. (2021)	88 students (m = 21yrs) 56% female EMA Characteristics: mean duration: 67 days, 1 per day (randomly between 9am and 8pm).	Passive Mobile Sensoring: Daily total distance travelled (km)	How stressed are you? (daily)	Two step multilevel vector autoregressive model.	No association between movement and stress the next day.	↑ movement associated with ↓ stress the next day.
Hallman and Lyskov (2012)	47 adults 23 Pain Group: (m = 41yrs), 91% female 22 Healthy Control: (m = 41yrs) 91% female EMA Characteristics: 24 h, 5x daily	Activity Monitor: Overall intensity values for 24 h for sitting, walking, standing, lying. Also split into values for 6pm–10pm, first hour after waking, 9am-12pm and 12pm-4pm.	Stress energy questionnaire Stress subscale: low and high activation adjectives (past 10 min)	Correlations	↑ walking in the evening associated with ↓ stress at bedtime.	Not analysed.
Jones et al. (2017)	105 adults, (m = 40yrs) 72% female EMA Characteristics: 4 days (Saturday-Tuesday), 8x daily	Accelerometer: Total minutes of light, moderate, vigorous PA and SB 15 min before or after EMA assessment	How stressed were you? (right before the assessment)	Mixed multilevel models.	No association between SB, light PA or MVPA and subsequent stress.	↑ SB 15 min prior to stress question associated with ↓ stress. ↑ Light PA 15 min prior to stress question associated with ↑ stress. No associations between MVPA and subsequent stress.
Kolar et al. (2020)	62 adolescents Anorexia Nervosa: 32 (m = 16yrs) Healthy Control: 30 (m = 16yrs), 100% female EMA Characteristics: 1 day (hourly 7am-11pm)	Accelerometer: Minutes of PA (30 min prior to EMA assessments, all levels of PA based on activity counts).	At this time, how intense is your emotional tension?	Linear mixed model	Not analysed.	PA in previous 30 min not associated with aversive tension (in either group).
Pinto et al. (2020)	20 adults (m = 52yrs) Breast cancer survivors EMA Characteristics: 12 months, assessments at 0, 3, 6, 9, 12 months 7 days EMA each time4x daily (8–11am, 11am-2pm, 2–5pm, 5–8pm)	Accelerometer: Activity Counts (SB) Self-Report: What are you doing now? (Includes leisure and non-leisure SB)	How stressed do you feel right now?	Longitudinal mixed effects model Cross-lagged models.	Not analysed.	SB in previous 3 h not associated with stress
Schultchen et al. (2019)	51 students (m = 24yrs), 80% female EMA Characteristics: 7 days 6x daily (9am, 11:30, 2pm, 4:30pm, 7pm, 9:30pm)	Accelerometer: Time in minutes Self-Report: How many minutes have you been physically active since the last	Perceived stress (2 items PSS) "Do you feel that you can cope with things" "Do you feel you're on top of	Hierarchical linear models	Not analysed.	↑ PA associated with ↓ stress in the subsequent 2.5 h.

(*continued on next page*)

Table 3 (*continued*)

Author	Participants, EMA Duration and Assessments	PA/SB Measure	Stress Measure	Analysis	PA/SB-Stress associations from Between–Person analysis	PA/SB-Stress associations from Within–Person analysis
		signal (sweated or out of breath)	things", and do you feel nervous/stressed (at time of assessment)			
Smith et al. (2021)	77 adolescents (m = 15yrs), 42% female EMA Characteristics: 7 days, every 2 h (3pm–9pm weekdays, 10am- 10pm weekends)	Accelerometer: Total activity counts and minutes of moderate to vigorous PA 60 min prior to stress measure.	Are you stressed? Yes/no Stress eating (is the answer yes to are you stressed, while eating) (at the time of assessment)	Generalised estimating equations	↑ MVPA in previous 60 min associated ↓ stress eating	MPVPA in previous 60 min not associated with stress eating
Lee et al. (2021)	478 adults (m = 50yrs) 51% female EMA Characteristics: 2 weeks, 3x daily (7am-11:59am, 12pm-4:59pm, 5pm-9:59pm)	Self-report: Did you exercise yesterday? (Y/N) (first prompt of the day)	To what extent do you feel stressed right now? (daily average calculated)	Fixed effect model	Not analysed.	No association between exercise on previous day and stress next day.
Park et al. (2022)	605 adults (m = 45yrs) 54% female EMA Characteristics: 8/9 days, 1 per day (7pm)	Self-Report: Did you do any sport, exercise or leisure time physical activity today? (Y/N)	How stressed do you feel right now?	General estimating equations	Not analysed	LTPA during the day associated with ↓ stress in the evening.
Sala et al. (2017)	129 students (m = 20yrs), 100% female EMA Characteristics: 7 days, 4x daily (1 per 3-h block)	Self-report: How long did you exercise since your last check in?	DASS- stress subscale (at the time of assessment)	Generalised linear mixed model	Not analysed.	No association between PA and stress in subsequent 3 h.
N-of 1 associations between Physical Activity/Sedentary Behaviour and Stress						
Burg et al. (2017)	69 adults (m = 32yrs), 57% female EMA Characteristics: 12 months 5x daily 1 x morning, 1 x evening, 3 random prompts per day (between 7am and 10pm)	Activity monitor (Fitbit): PA day: a day with any 30-min period of MVPA Self-Report: How likely are you to exercise today? (AM assessment) Have you exercised for 30 min or more today? (Evening assessment)	how stressful do you expect today to be? (AM assessment)How stressful was your day? (evening assessment) How stressful do you think your day will be tomorrow? (evening) Key sources of stress (list of options) 4 item PSS (both at each assessment)	Random coefficient linear regression models	Due to high individual variation, overall no association between physical activity and stress or stress and physical activity.	
Bos et al. (2018)	40 adults 20 anhedonic (m = 40yrs), 95% female 20 non-anhedonic (m = 44yrs), 95% female (matched on depression) EMA Characteristics: 30 days, 3x daily	Self-report "I was physically active" (not at all- very much) (since the last measurement)	"I am upset"	Vector autoregression (VAR) model with cumulative impulse response function	Stress experience associated with ↓ PA at next measurement.	
Cheung et al. (2017)	79 healthy adults (m = 32yrs) 57% female EMA Characteristics: 1 year, 5x daily	Activity monitor (Fitbit): PA day: a day with any 30-min period of MVPA Self-Report: How likely are you to exercise today for 30 min or more at MVPA? (AM assessment) Did you exercise today for 30 min or more at MVPA? (evening assessment)	How stressed did you feel? (just before assessment) How stressful do you expect today to be? (AM assessment) How stressful do you think tomorrow will be? (evening assessment)	Classification decision tree, applied random forest to yield ranking of variable importance, select variables that lead to standardised decrease in classification accuracy.	When stress was experienced, participants were less likely to be physically active 2 days later. No significant associations between PA and stress/stress and PA.	

Note: EMA = Ecological Momentary Assessment PA = Physical Activity, SB = Sedentary Behaviour, MVPA = Moderate to Vigorous Physical Activity, LTPA = Leisure Time Physical Activity, LPA = Light Physical Activity PSS = perceived stress scale, GLT = Godin Leisure Time Exercise Questionnaire, DASS- Depression, Anxiety and Stress Scales.

related to more PA up to 2 h later.

Four studies examined the prospective between-person associations of PA predicting subsequent stress in adults (n = 2), students (n = 1), or adolescents (n = 1), using objective measures of PA and mostly perceived stress (see Table 3). Whereas walking after work was associated with lower stress at bedtime (Hallman & Lyskov, 2012) and PA in the previous hour with less stress-relating eating (Smith et al., 2021), other studies reported no such associations (daSilva et al., 2021; Jones et al., 2017).

Prospective Analysis – Within-Person: Fourteen studies examined the prospective within-person associations of stress predicting subsequent PA in adults (n = 9), students (n = 3), or children (n = 2). Studies used either accelerometer or self-report measures of PA, and a mix of stress measures, but most commonly studies measured feelings of stress (see Table 3). The findings are mixed. Seven studies reported no associations between stress and subsequent PA (Almeida et al., 2020; Anderson & Fowers, 2020; Calderwood et al., 2021; Lin et al., 2021; Nägel et al., 2015; Payne et al., 2010; Sala et al., 2017). Seven studies reported associations between stress and subsequent PA, but the direction of the associations varied. More specifically, five studies reported that higher

Table 4
Summary of the direction of findings for concurrent and prospective associations.

	Concurrent analyses						Prospective analyses					
	Between-person associations			Within-person associations			Between-person associations			Within-person associations		
	Positive	Negative	Null	Positive	Negative	Null	Positive	Negative	Null	Positive	Negative	Null
Stress-PA	0	0	0	2	1	2	1	0	5	2	5	7
PA-Stress	0	0	3	0	0	6	0	2	2	1	4	4
Stress-SB	0	0	0	1	2	1	0	0	0	0	1	2
SB-Stress	0	0	0	0	0	0	0	0	0	0	1	1

Note: total values may add up to more than total number of studies due to multiple findings. PA = physical activity, SB = sedentary behaviour.

stress was associated with less subsequent PA (Abdel Hadi et al., 2021; daSilva et al., 2021; Do et al., 2021; Naya et al., 2021; Schultchen et al., 2019) with timeframes ranging from 10 min to the next day. Other studies reported stress to be associated with more PA (Almeida et al., 2020) (study 2) Jones et al. (2017) also found that stress was associated with more PA, but this association was only evident for light PA, no association was reported between stress and moderate to vigorous physical activity (MVPA).

Nine studies examined the prospective within-person associations of PA predicting subsequent stress in adults (n = 5), students (n = 2) or adolescents (n = 2). Studies used either accelerometer or self-report measures of PA and measures of stress were predominately focussed on feelings of stress (see Table 3). Four studies reported no within-person association between PA and subsequent stress levels (Kolar et al., 2020; Lee et al., 2021; Sala et al., 2017; Smith et al., 2021). Four studies reported that PA was negatively associated with subsequent stress up to one day later (Abdel Hadi et al., 2021; daSilva et al., 2021; Park. et al., 2022; Schultchen et al., 2019). The only study reporting a positive association between PA and stress found that light PA was associated with subsequent stress, whereas MVPA was not associated with subsequent stress (Jones et al., 2017).

When examining whether PA was associated with subsequent stress, there did not appear to be any consistent methodological differences that could account for significant or non-significant findings (see Table 3).

N-of-1 analyses - Concurrent: The only study to examine within-person concurrent N-of-1 associations of overall daily stress predicting self-reported PA, reported a median negative correlation at participant level but did not conduct formal statistical analyses (Comulada et al., 2018).

N-of-1 analyses - Prospective: Burg et al. (2017), Cheung et al. (2017) and Bos et al. (2018) used N-of 1 analyses to explore within-person associations of stress predicting PA. When looking at overall group associations, Cheung et al. (2017) reported that if stress is experienced, a person was less likely to exercise 2 days later, but stress was only a predictor for exercise in 5 out of 79 participants, suggesting no overall significant relationship. In line with this, Burg et al. (2017) found there was a great deal of inter-participant variation, with data from the majority of participants not indicating a significant relationship between PA and stress (or vice versa). Similarly, Bos et al. (2018) reported that more stress was associated with lower PA.

3.3. Sedentary behaviour

Concurrent Analysis – Between-Person: No studies explored between-person associations between stress and SB or SB and stress.

Concurrent Analysis – Within-Person: Four studies examined the concurrent within-person associations between stress and SB in adults (n = 4), using objective measures of SB and a variety of stress measures (see Table 2). Diaz et al. (2018) found that although stress at the end of the day was not associated with overall sitting time, lower end of the day stress was associated with more bouts of SB with a duration of ≥90 min. Lin et al. (2021) and Liao et al. (2015) found that increased stress was associated with more SB, whereas Zenk et al. (2017) found that experiencing more hassles was related to lower SB.

Prospective Analysis – Within-Person: Three studies examined the prospective within-person associations between stress and subsequent SB in adults. Accelerometer measures of SB were used in all studies, with Pinto et al. (2020) also using a self-report measure, and measures of stress were feelings of stress(see Table 3). Two studies reported no associations between SB and subsequent stress (Lin et al., 2021; Pinto et al., 2020). Jones et al. (2017) found that higher levels of stress were associated with lower SB in the subsequent 15 min.

Of the two studies which examined the prospective within-person associations between accelerometer measured SB and subsequent stress (feelings of stress), one found that higher SB in the 15 min prior was associated with lower stress (Jones et al., 2017), but the other study reported no association between SB in the previous 3 h and stress levels (Pinto et al., 2020).

4. Discussion

The present review set out to investigate the concurrent and prospective associations between PA/SB and stress and vice versa in studies using EMA methodologies. A clear strength of EMA studies is the ability to explore the associations between outcomes at a within-person level, and more specifically explore the impact of stress on subsequent PA/SB or the impact of PA/SB on subsequent levels of stress. It is therefore not surprising that within-person analyses, and in particular prospective within-person analyses have been most frequently reported in the studies reviewed focussing on stress and PA. The within-person associations between stress and subsequent PA, and PA and subsequent stress were mixed. Approximately half of the within-person studies reported no associations, while the other half reported that stress was negatively associated with subsequent PA and PA was negative associated with subsequent stress (see Table 4 for summary). Between-person associations between stress and subsequent PA and PA and subsequent stress were mostly non-significant. The majority of studies exploring concurrent associations reported no significant between- or within-person association between stress and PA. Considerably less studies examined the associations between stress and SB or SB and stress. The results of these studies, which only included within-person analyses, are mixed.

The findings from prospective within-person associations between stress and subsequent PA were equivocal. Those that report an association tended to show that stress is related to reduced PA with lag times ranging from 30 min to the next day (Abdel Hadi et al., 2021; daSilva et al., 2021; Do et al., 2021; Naya et al., 2020; Schultchen et al., 2019). Half of the studies reported no within-person association between stress and subsequent PA. Measures of stress or PA, or different lag times cannot explain these different findings. However, closer inspection showed that while these non-significant findings applied to whole samples, personal characteristics of participants influenced the associations between stress and subsequent PA. More specifically, there were negative associations between stress and subsequent PA in people with low motives for exercise, whereas positive associations were evident between stress and subsequent PA in those with higher motivation for exercise (Nagel et al., 2015). Similarly, in participants with lower levels of eating disorder-related symptoms (i.e., drive for thinness, bulimic

symptoms, and body dissatisfaction), stress was related to increased subsequent PA, but this relationship was not evident in those with moderate or high levels of symptoms associated with eating disorders (Sala et al., 2017). Additionally, even though not prospective analyses, concurrent associations between stress and PA were only shown in those who had strong beliefs of PA as a way to cope with stress (Dalton, 2020). Within-person associations between PA and subsequent stress reported an equal amount of non-significant associations as positive associations. Again, there are no apparent systematic differences in stress or PA measures, or lag times to explain these differences. Only one study examined interaction effects of individual characteristics on these associations and reported a significant impact of BMI on the association between PA and stress eating; for those with high BMI, PA was related to lower levels of stress, whereas the reverse was found for those with low BMI. Taken together, there is emerging evidence that individual characteristics can influence the association between stress and PA and PA and stress. This has been previously suggested in the review conducted by Stults-Kolehmainen and Sinha (2014), who mentioned that those who were regular exercisers may exercise more during times of stress. Therefore, to get a deeper understanding of the these within-person associations, it is important to take personal characteristics into consideration beyond the commonly examined covariates (e.g., age, gender).

Several studies explored the bidirectional associations between stress and subsequent PA and PA and subsequent stress in the same participants (Abdel Hadi et al., 2021; daSilva et al., 2021; Jones et al., 2017; Sala et al., 2017; Schultchen et al., 2019). It was most commonly found that stress was related to lower PA, and PA was associated with lower stress (Abdel Hadi et al., 2021; daSilva et al., 2021; Schultchen, 2019). Moreover, PA was reported to mediate the association between job demands and perceived stress in the evening (Abdel Hadi et al., 2021). These different sequential associations emphasise the importance of using EMA methods to determine the associations between stress and PA, which are not captured when participants are asked to rate their stress and PA levels as an overall average of a period of several days or a week. Furthermore, these observed associations also suggest that PA should be recommended as a way to reduce perceived stress.

Two studies reported stress to be associated with increased subsequent PA (Almeida et al., 2020; Jones et al., 2017), and one study reported PA to be associated with increased subsequent stress (Jones et al., 2017). Closer inspection of these studies revealed a potential impact of the type of PA (Jones et al., 2017) or the way stress is assessed (Almeida et al., 2020). Higher levels of stress were associated with more light intensity PA but not MVPA in the subsequent 15 min. Similarly, light intensity PA, but not MVPA, was associated with more stress in the subsequent 15 min (Jones et al., 2017). Further exploration of the light physical activities showed that participants generally reported doing chores, such as getting ready for work or cooking. Therefore, the reason or purpose of this type of activity could potentially be perceived as stressful itself and could have contributed to the higher stress level 15 min later. Unfortunately, no information was provided about the types of activities that were conducted during moderate to vigorous PA, therefore it is not possible to determine if the difference in associations between stress and light PA and stress and MVPA can be contributed to the intensity of the activity or the type of activity. In addition to the intensity or type of activity, the context in which PA is done has not been explored in detail. The health benefits of leisure time PA have been well documented, whereas occupational PA has been reported to be associated with negative health implications (Bonekamp et al., 2022). Some studies have specifically focussed on PA during work (Calderwood et al., 2021) and PA after work (e.g., Abdel Hadi et al. (2021), Nägel et al. (2015)), but without a direct comparison it is difficult to determine if there is a differential impact of leisure versus occupation PA on stress. Similarly, research has also suggested that being physically active outdoors has better mental health outcomes than being active indoors (Bowler et al., 2010; Dunton et al., 2015), so activity location could also be important to consider. In sum, in order to get a better understanding of the associations between stress and PA, future research is needed to explore the impact of PA intensity and context.

Different measures of stress were used when comparing the studies included in the review, which could potentially be a reason for some of the equivocal results. The importance of the way stress is measured is particularly evident from one of the studies conducted by Almeida et al. (2020). A positive association was reported between perceived stress and subsequent PA, but when stress was quantified as an accumulation of stressful events, it was negatively associated with subsequent PA. This suggests that the appraisal of a stressful event has a different association with PA compared to the association of the occurrence of a stressful event with PA. While being physically active does not remove the stressor, being physically active could perhaps help a person cope better with the feelings of stress, which could in turn influence ratings of how stress is experienced. The findings mentioned earlier that in those who had stronger beliefs that PA could be a way to cope with stress, stress was negatively associated with PA provides some support for this suggestion (Dalton, 2020). Positive and negative affect are also likely to play a role in the associations between stress and PA. Previous research has suggested that negative affect is associated with lower levels of PA (Niermann et al., 2016), and PA is associated with increased positive affect (e.g., happiness and feeling energetic) (Liao et al., 2015). Positive affect has also been suggested to buffer against negative stress responses (van Steenbergen et al., 2021). Even though studies have often included both assessments of affect and stress, the interactions between stress, PA, and affect have not been explored in detail and warrants further investigation.

The results for the within-person associations between concurrent stress and PA were mixed. Only when a measure of perceived stress was used, was stress significantly associated with less PA (daSilva et al., 2021). When stress was quantified as daily work hassles or occurrence of stressful events, stress was either not associated (Lin et al., 2021; Määttänen et al., 2021) or more stress was associated with more PA (Gloster, 2017; Zenk et al., 2017). However, when exploring the concurrent associations between PA and stress, no significant associations were reported, regardless of measuring perceived stress (Anderson & Fowers, 2020; Li et al., 2019; Strahler et al., 2020; Zawadzki et al., 2015) or number of stressors (Dalton, 2020; Igic et al., 2013). In line with aforementioned comments made about the prospective analyses, it is possible that the concurrent associations are influenced by other factors that could contribute to the overall equivocal findings. However, only Määttänen et al. (2021) explored the influence of other factors on the concurrent association between stress and PA. They found that social company (i.e., being with friends, with no one, or with other people) did not impact on the association between stress and PA. Therefore, more studies are needed to examine the impact personal and contextual factors have on the concurrent within-person associations between stress and PA.

As mentioned earlier, a limited number of studies explored the between-person associations between stress and PA. None of the three studies that explored concurrent associations between PA and stress found significant between-person associations (Anderson & Fowers, 2020; Li et al., 2020; Lindberg et al., 2018). This is in contrast with the previous review exploring stress and PA, where, even though not confirmed by all studies, there was stronger evidence for an association between stress and PA (Stults-Kolehmainen & Sinha, 2014). Methodological differences in data collection could be a reason for these differences. In the studies reported in this review, participants were asked to report on their levels of stress and PA at a regular basis (e.g., hourly, once per day). For the between-person analyses in the current review, measurements taken at all assessment points were averaged to provide an overall average value for each outcome per participant. The majority of the assessments in the previous review by Stults-Kolehmainen and Sinha (2014) included measures that represented the participant's reflection and memory of their overall perceived stress in the previous

week. In contrast, deriving the average value based on data collected using EMA methods captures variations within and between days in the outcome measures, without relying on recall of the participant, and could arguably be a better reflection of their perceived levels of stress.

Looking at the prospective between-person analyses, stress was associated with subsequent PA in only one study (Almeida et al., 2020), and five studies reported no association (Almeida et al., 2020; daSilva et al., 2021; Do et al., 2021; Jones et al., 2017; Naya et al., 2020). Interestingly, Almeida et al. (2020) reported two separate studies with similar designs, but only reported a significant positive association between stress and PA in one of the studies. The associations between PA and subsequent stress were more varied, with two studies reporting a negative association (Hallman & Lyskov, 2012; Smith et al., 2021) and two finding no association (daSilva et al., 2021; Jones et al., 2017). Again, study designs were similar in these studies.

So far, the discussion has focussed on the associations between stress and PA. The findings related to concurrent and prospective within-person associations between stress and SB are equivocal. No studies reported the between-person associations of stress and SB. Given the limited number of studies exploring stress and SB, there is not sufficient evidence for statements about whether or not associations exist. Similar to the discussion about the context of PA, the context of sitting is likely to influence the association between SB and stress. More broadly, there is increasing evidence for differential health benefits of different 'types' of sitting. For example, mentally active sedentary behaviour (e.g., office-based work) and mentally passive sedentary behaviour (e.g., watching tv) have differential relationships with psychological health (Hallgren et al., 2020). In addition, other behaviours done while sitting could influence the impact on overall wellbeing, such as poor diet or smoking. Only Pinto et al. (2020) included assessments of both objective and self-report (leisure, non-leisure) measures of sitting. However, they did not report the influence of the type of SB on perceived stress. Therefore, current data available from EMA studies is not sufficient enough to determine the associations between stress and SB, and further research is needed to explore the impact of different types of sitting on perceived stress.

5. Recommendations, limitations and future research implications

To the best of our knowledge, this is the first scoping review to investigate the relationship between PA and stress when using EMA, providing a valuable initial insight into the topic area. In contrast to the previous review by Stults-Kolehmainen and Sinha (2014), which examined a range of research designs, methodologies, and statistical approaches, and focused mainly on the effect of stress on PA, the current review focusses in on the specific methodology of EMA. The current review also explored the associations between stress and PA/SB as well as PA/SB and stress, and therefore provided additional information about the bidirectional nature of the PA/SB and stress relationship not included in the previous review. In addition, the current review comments on the potential influence of personal characteristics on the PA/SB and stress relationship and highlights the use of statistical analyses to further explore these additional characteristics. Consequently, the present review provides more insight into the stress and PA/SB relationship.

The review however is not without its limitations. In many of the studies included, investigating the relationship between stress and PA was not the primary aim, meaning that the stress/PA relationship may not have been fully explored (e.g., only presenting a correlation for PA/stress when there are full lagged analyses for other variables), or the study may not have sufficient statistical power to explore these associations. This could mean that relationships are missed entirely or presented as non-significant, where more in depth analysis may have shown an association. Future directions for research should aim to address this limitation, with studies using EMA having a primary aim of looking at the associations between PA/SB and stress to allow for a more comprehensive view. Studies should take into consideration the number of assessments and the types of stress and PA/SB measures used, and which participant characteristics could influence the potential associations between PA/SB and stress.

6. Conclusion

In conclusion, there is a growing body of literature exploring the associations between stress and PA/SB and PA/SB and stress using EMA methodologies. Overall findings appear to be mixed, however there appears to be some evidence for stress to be associated with subsequent lower levels of PA and PA to be associated with lower levels of stress. Future research should investigate the impact of the way stress is quantified, different intensities of PA and the context of both PA and SB in order to get a better understanding of the associations between stress and PA/SB. In addition, more detailed studies are needed to explore personal and contextual factors that could influence these associations is warranted.

Funding

This study was funded as part of the Global Challenges PhD studentship at the University of Birmingham, UK.

Declaration of competing interest

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.

Data availability

Data will be made available on request.

References

daSilva, A. W., Huckins, J. F., Wang, W., Wang, R., Campbell, A. T., & Meyer, M. L. (2021). Daily perceived stress predicts less next day social interaction: Evidence from a naturalistic mobile sensing study. *Emotion, 21*(8), 1760–1770. https://doi.org/10.1037/emo0000994

Abdel Hadi, S., Mojzisch, A., Krumm, S., & Hausser, J. A. (2021). *Day-level relationships between work, physical activity, and well-being: Testing the physical activity-mediated demand-control (pamdc) model* [References]. *Work & Stress* https://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=psyc18&AN=2022-07099-001 https://birmingham-primo.hosted.exlibrisgroup.com/openurl/44BIR/44BIR_Services?sid=OVID:psycdb&id=pmid:&id=doi:10.1080%2F02678373.2021.2002971&issn=0267-8373&isbn=&volume=&issue=&spage=No&pages=No+Pagination+Specified&date=2021&title=Work+%26+Stress&atitle=Day-level+relationships+between+work%2C+physical+activity%2C+and+well-being%3A+Testing+the+physical+activity-mediated+demand-control+%28pamdc%29+model.&aulast=Abdel+Hadi&pid=%3Cauthor%3EAbdel+Hadi%2C+Sascha%3C%2Fauthor%3E%3CAN%3E2022-07099-001%3C%2FAN%3E%3CDT%3E%3C%2FDT%3E.

Almeida, D. M., Marcusson-Clavertz, D., Conroy, D. E., Kim, J., Zawadzki, M. J., Sliwinski, M. J., & Smyth, J. M. (2020). Everyday stress components and physical activity: Examining reactivity, recovery and pileup. *Journal of Behavioral Medicine, 43*(1), 108–120. https://link.springer.com/content/pdf/10.1007/s10865-019-00062-z.pdf.

Anderson, E., & Durstine, J. L. (2019). Physical activity, exercise, and chronic diseases: A brief review. *Sports Medicine and Health Science, 1*(1), 3–10.

Anderson, A. R., & Fowers, B. J. (2020). Lifestyle behaviors, psychological distress, and well-being: A daily diary study. *Social Science & Medicine, 263*, Article 113263.

Bonekamp, N. E., Visseren, F. L., Ruigrok, Y., Cramer, M. J., de Borst, G. J., May, A. M., & Koopal, C. (2022). *Leisure-time and occupational physical activity and health outcomes in cardiovascular disease*. Heart.

Bos, F., Blaauw, F., Snippe, E., Van der Krieke, L., De Jonge, P., & Wichers, M. (2018). Exploring the emotional dynamics of subclinically depressed individuals with and without anhedonia: An experience sampling study. *Journal of Affective Disorders, 228*, 186–193. https://core.ac.uk/download/pdf/153217471.pdf.

Bowler, D. E., Buyung-Ali, L. M., Knight, T. M., & Pullin, A. S. (2010). A systematic review of evidence for the added benefits to health of exposure to natural environments. *BMC Public Health, 10*(1), 1–10. https://link.springer.com/article/10.1186%2F1471-2458-10-571.

Burg, M. M., Schwartz, J. E., Kronish, I. M., Diaz, K. M., Alcantara, C., Duer-Hefele, J., & Davidson, K. W. (2017). Does stress result in you exercising less? Or does exercising result in you being less stressed? Or is it both? Testing the bi-directional stress-exercise association at the group and person (N of 1) level. *Annals of Behavioral Medicine, 51*(6), 799–809. https://watermark.silverchair.com/12160_2017_article_9902.pdf?token=AQECAHi208BE49Ooan9kkhW_Ercy7Dm3ZL_9Cf3qfKAc485ysgAAAu8wggLrBgkqhkiG9w0BBwagggLcMIIC2AIBADCCAtEGCSqGSIb3DQEHATAeBglghkgBZQMEAS4wEQQMz5dw_qyTTxDCZn-_AgEQgIICoho9RDSBcIT_QG5MgCS03w7c4Su0ZnIDSEqm3kw0swi-j2AJOaec2j1xbN7T5IVQqybcfh-_GmElx5J6p4zuCbH6v96-QiiS_inBOEE-eBgdWpbOMaVGgvWglOv71e3eoHlETLHQAha7y6eFUMwfFL5mywjfWpgJ46t9o5K8yilizdXozRC3RuqPcIC8BLs3x6B99pAe8Z_XDZMGTb4vTVmRvhIvh9uaCyT00UntZfnFI3145b9sbk1z6NGbnoKixAzI7b5RYJuc-wsYPkdzg14YvBalpAPWteM-gcaDgf9lKO9z4nhaZgn_hgd4QNinLr3v2hSbctiq8JOFxiw3Boi1kLpykCFT24XCK8o22SyjBKNUJnbuYheFEShUQ1ZCHUHtSQAkll19UJnvqaZMRkmT63RnozEfzGM0OUJ9W7xaQelTuV2PPD7uLj4yGFXJ1A0-TwCK3UWlp4knNaF0oNNu8TTPVZwKYwqvy5A0sq1s6A5jE6CJ7KEh8QmZLL30Z-YZ-2dwMKX9KwPhGBaO1_Ze7MNrE13tIv2lNe-lIloJHxUsggGRCnbZmx0ldxopdaNvUWE9b86Kd8B4A1XZdv2zyjcEbix6fz7wfXKMRDe645_scw2SbQGJQM09MaYQaS7gaLLj7_gNZj0tGBJTP2oRy-tABp4rPHhGBD7hzuMIvuSgnKnYcJ9PJMYrNV_UnSBUXoJPFMQumC3mEKKLIgIPtXgw7pz68t8_r1DCmNQ3lylZGtmNc-knsg6B6bciHvNfzNzxr3AYfOvva55uQsFMQnuqHH7BqhyQtifbQZsOY5KPcWX0i5Xd3IpX8-krcnISHNoayDqdm5F885y7VPyZG5LVjc2J5rzO9zpvxGMtHHSDYCaOaH0oCzyxOSRxL14R.

Calderwood, C., Gabriel, A. S., Ten Brummelhuis, L. L., Rosen, C. C., & Rost, E. A. (2021). Understanding the relationship between prior to end-of-workday physical activity and work–life balance: A within-person approach. *Journal of Applied Psychology, 106*(8), 1239.

Cheung, Y. K., Hsueh, P.-Y. S., Qian, M., Yoon, S., Meli, L., Diaz, K. M., Schwartz, J. E., Kronish, I. M., & Davidson, K. W. (2017). Are nomothetic or ideographic approaches superior in predicting daily exercise behaviors? *Methods of Information in Medicine, 56*(6), 452–460.

Comulada, W. S., Swendeman, D., Rezai, R., & Ramanathan, N. (2018). Time series visualizations of mobile phone-based daily diary reports of stress, physical activity, and diet quality in mostly ethnic minority mothers: Feasibility study. *JMIR formative research, 2*(2), Article e11062.

Curran, P. J., & Bauer, D. J. (2011). The disaggregation of within-person and between-person effects in longitudinal models of change. *Annual Review of Psychology, 62*, 583–619. https://www.annualreviews.org/doi/pdf/10.1146/annurev.psych.093008.100356.

Dalton, E. D. (2020). Exercise-related coping beliefs predict physical activity levels in response to naturally occurring stress: A daily diary study of college students. *Journal of American College Health*, 1–9.

Diaz, K. M., Thanataveerat, A., Parsons, F. E., Yoon, S., Cheung, Y. K., Alcántara, C., Duran, A. T., Ensari, I., Krupka, D. J., & Schwartz, J. E. (2018). The influence of daily stress on sedentary behavior: Group and person (N of 1) level results of a 1-year observational study. *Psychosomatic Medicine, 80*(7), 620. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6113063/pdf/nihms969457.pdf.

Do, B., Mason, T. B., Yi, L., Yang, C. H., & Dunton, G. F. (2021). Momentary associations between stress and physical activity among children using ecological momentary assessment. *Psychology of Sport and Exercise, 55*. https://doi.org/10.1016/j.psychsport.2021.101935

Dunton, G. F. (2017). Ecological momentary assessment in physical activity research. *Exercise and Sport Sciences Reviews, 45*(1), 48. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5161656/pdf/nihms819740.pdf.

Dunton, G. F., Liao, Y., Intille, S., Huh, J., & Leventhal, A. (2015). Momentary assessment of contextual influences on affective response during physical activity. *Health Psychology, 34*(12), 1145.

Ekelund, U., Brown, W. J., Steene-Johannessen, J., Fagerland, M. W., Owen, N., Powell, K. E., Bauman, A. E., & Lee, I.-M. (2019). Do the associations of sedentary behaviour with cardiovascular disease mortality and cancer mortality differ by physical activity level? A systematic review and harmonised meta-analysis of data from 850 060 participants. *British Journal of Sports Medicine, 53*(14), 886–894.

von der Embse, N., & Mankin, A. (2021). Changes in teacher stress and wellbeing throughout the academic year. *Journal of Applied School Psychology, 37*(2), 165–184.

Fink, G. (2016). Stress, definitions, mechanisms, and effects outlined: Lessons from anxiety. In *Stress: Concepts, cognition, emotion, and behavior* (pp. 3–11). Elsevier.

Gianfredi, V., Blandi, L., Cacitti, S., Minelli, M., Signorelli, C., Amerio, A., & Odone, A. (2020). Depression and objectively measured physical activity: A systematic review and meta-analysis. *International Journal of Environmental Research and Public Health, 17*(10), 3738.

Gloster, A. T., A H, M., Witthauer, C., Lieb, R., & Mata, J. (2017). 'I feel better when...': An analysis of the memory-experience gap for peoples' estimates of the relationship between health behaviours and experiences. *Psychology and Health, 32*(9), 1152–1166. https://doi.org/10.1080/08870446.2017.1327586

Gloster, A. T., Meyer, A. H., Witthauer, C., Lieb, R., & Mata, J. (2017). 'I feel better when…': An analysis of the memory-experience gap for peoples' estimates of the relationship between health behaviours and experiences. *Psychology and Health, 32*(9), 1152–1166.

Hallgren, M., Owen, N., Stubbs, B., Vancampfort, D., Lundin, A., Dunstan, D., Bellocco, R., & Lagerros, Y. T. (2020). Cross-sectional and prospective relationships of passive and mentally active sedentary behaviours and physical activity with depression. *The British Journal of Psychiatry, 217*(2), 413–419.

Hallman, & Lyskov. (2012). Autonomic regulation, physical activity and perceived stress in subjects with musculoskeletal pain: 24-hour ambulatory monitoring. *International Journal of Psychophysiology, 86*(3), 276–282. https://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=med9&AN=23075754. https://birmingham-primo.hosted.exlibrisgroup.com/openurl/44BIR/44BIR_Services?sid=OVID:medline&id=pmid:23075754&id=doi:10.1016%2Fj.ijpsycho.2012.09.017&issn=0167-8760&isbn=&volume=86&issue=3&spage=276&pages=276-82&date=2012&title=International+Journal+of+Psychophysiology&atitle=Autonomic+regulation%2C+physical+activity+and+perceived+stress+in+subjects+with+musculoskeletal+pain%3A+24-hour+ambulatory+monitoring.&aulast=Hallman&pid=%3Cauthor%3EHallman+DM%3C%2Fauthor%3E%3CAN%3E23075754%3C%2FAN%3E%3CDT%3EJournal+Article%3C%2FDT%3E.

Hallman, D. M., & Lyskov, E. (2012). Autonomic regulation, physical activity and perceived stress in subjects with musculoskeletal pain: 24-hour ambulatory monitoring. *International Journal of Psychophysiology, 86*(3), 276–282.

Hammen, C., Kim, E. Y., Eberhart, N. K., & Brennan, P. A. (2009). Chronic and acute stress and the prediction of major depression in women. *Depression and Anxiety, 26*(8), 718–723.

Igic, Ryser, S., & Elfering, A. (2013a). Does work stress make you shorter? An ambulatory field study of daily work stressors, job control, and spinal shrinkage. *Journal of Occupational Health Psychology, 18*(4), 469–480. https://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=emed14&AN=372263293. https://birmingham-primo.hosted.exlibrisgroup.com/openurl/44BIR/44BIR_Services?sid=OVID:embase&id=pmid:24099165&id=doi:10.1037%2Fa0034256&issn=1076-8998&isbn=&volume=18&issue=4&spage=469&pages=469-480&date=2013&title=Journal+of+Occupational+Health+Psychology&atitle=Does+work+stress+make+you+shorter%3F+An+ambulatory+field+study+of+daily+work+stressors%2C+job+control%2C+and+spinal+shrinkage&aulast=Igic&pid=%3Cauthor%3EIgic+I.%3C%2Fauthor%3E%3CAN%3E372263293%3C%2FAN%3E%3CDT%3EArticle%3C%2FDT%3E.

Igic, I., Ryser, S., & Elfering, A. (2013b). Does work stress make you shorter? An ambulatory field study of daily work stressors, job control, and spinal shrinkage. *Journal of Occupational Health Psychology, 18*(4), 469.

Jamieson, J. P., Crum, A. J., Goyer, J. P., Marotta, M. E., & Akinola, M. (2018). Optimizing stress responses with reappraisal and mindset interventions: An integrated model. *Anxiety, Stress & Coping, 31*(3), 245–261.

Jones, M., Taylor, A., Liao, Y., Intille, S. S., & Dunton, G. F. (2017). Real-time subjective assessment of psychological stress: Associations with objectively-measured physical activity levels. *Psychology of Sport and Exercise, 31*, 79–87. https://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=psyc14&AN=2017-25539-012. https://birmingham-primo.hosted.exlibrisgroup.com/openurl/44BIR/44BIR_Services?sid=OVID:psycdb&id=pmid:&id=doi:10.1016%2Fj.psychsport.2017.03.013&issn=1469-0292&isbn=&volume=31&issue=&spage=79&pages=79-87&date=2017&title=Psychology+of+Sport+and+Exercise&atitle=Real-time+subjective+assessment+of+psychological+stress%3A+Associations+with+objectively-measured+physical+activity+levels.&aulast=Jones&pid=%3Cauthor%3EJones%2C+Malia%3C%2Fauthor%3E%3CAN%3E2017-25539-012%3C%2FAN%3E%3CDT%3EJournal+Article%3C%2FDT%3E.

Kivimäki, M., & Steptoe, A. (2018). Effects of stress on the development and progression of cardiovascular disease. *Nature Reviews Cardiology, 15*(4), 215–229.

Kolar, D. R., Neumayr, C., Roth, M., Voderholzer, U., Perthes, K., & Schlegl, S. (2020). Testing an emotion regulation model of physical activity in adolescents with anorexia nervosa: A pilot ecological momentary assessment. *European Eating Disorders Review, 28*(2), 170–183. https://onlinelibrary-wiley-com.ezproxye.bham.ac.uk/doi/pdfdirect/10.1002/erv.2706.

Lee, S. S., Yu, K., Choi, E., & Choi, I. (2021). *To drink, or to exercise: That is (not) the question! Daily effects of alcohol consumption and exercise on well-being. Appl Psychol Health Well Being*. https://doi.org/10.1111/aphw.12319

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*, 1975 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4688389/pdf/fpsyg-06-01975.pdf.

Li, Y., Deng, J., Lou, X., Wang, H., & Wang, Y. (2019). A daily diary study of the relationships among daily self-compassion, perceived stress and health-promoting behaviours. *International Journal of Psychology*. No Pagination Specified https://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=psyc16&AN=2019-44994-001 https://birmingham-primo.hosted.exlibrisgroup.com/openurl/44BIR/44BIR_Services?sid=OVID:psycdb&id=pmid:&id=doi:10.1002%2Fijop.12610&issn=0020-7594&isbn=&volume=&issue=&spage=No&pages=No+Pagination+Specified&date=2019&title=International+Journal+of+Psychology&atitle=A+daily+diary+study+of+the+relationships+among+daily+self-compassion%2C+perceived+stress+and+health- promoting+behaviours.&aulast=Li&pid=%3Cauthor%3ELi%2C+Yanjuan%3C%2Fauthor%3E%3CAN%3E2019-44994-001%3C%2FAN%3E%3CDT%3E%3C%2FDT%3E.

Li, Y., Deng, J., Lou, X., Wang, H., & Wang, Y. (2020). A daily diary study of the relationships among daily self-compassion, perceived stress and health-promoting behaviours. *International Journal of Psychology, 55*(3), 364–372. https://onlinelibrary-wiley-com.ezproxye.bham.ac.uk/doi/pdfdirect/10.1002/ijop.12610.

Lindberg, C. M., Srinivasan, K., Gilligan, B., Razjouyan, J., Lee, H., Najafi, B., Canada, K. J., Mehl, M. R., Currim, F., Ram, S., Lunden, M. M., Heerwagen, J. H., Kampschroer, K., & Sternberg, E. M. (2018). Effects of office workstation type on physical activity and stress. *Occupational and Environmental Medicine, 75*(10), 689–695. https://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=emexa&AN=623741063. https://birmingham-primo.hosted.exlibrisgroup.com/openurl/44BIR/44BIR_Services?sid=OVID:embase&id=pmid:30126872&id=doi:10.1136%2Foemed-2018-105077&issn=1351-0711&isbn=&volume=75&issue=10&spage=689&pages=689-695&date=2018&title=Occupational+and+Environmental+Medicine&atitle=Effects+of+office+workstation+type+on+physical+activity+and+stress&aulast=Lindberg&pid=%3Cauthor%3ELindberg+C.M.%3C%2Fauthor%3E%3CAN%3E623741063%3C%2FAN%3E%3CDT%3EArticle%3C%2FDT%3E.

Lin, T. T., Jones, K. K., Martyn-Nemeth, P., & Zenk, S. N. (2021). Associations between daily work hassles and energy-balance behaviors in female african american workers: An ecological momentary assessment study. *Ethnicity & Disease, 31*(2), 177–186. https://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=emed22&AN=2011936743. https://birmingham-primo.hosted.exlibrisgroup.com/openurl/44BIR/44BIR_Services?sid=OVID:embase&id=pmid:33883858&id=doi:10.18865%2FED.31.2.177&issn=1049-510X&isbn=&volume=31&issue=2&spage=177&pages=177-186&date=2021&title=Ethnicity+and+Disease&atitle=Associations+between+daily+work+hassles+and+energy-balance+behaviors+in+female+african+american+workers%3A+An+ecological+momentary+assessment+study&aulast=Lin&pid=%3Cauthor%3ELin+T.-T.%3C%2Fauthor%3E%3CAN%3E2011936743%3C%2FAN%3E%3CDT%3EArticle%3C%2FDT%3E.

Määttänen, I., Henttonen, P., Väliaho, J., Palomäki, J., Thibault, M., Kallio, J., Mäntyjärvi, J., Harviainen, T., & Jokela, M. (2021). Positive affect state is a good predictor of movement and stress: Combining data from ESM/EMA, mobile HRV measurements and trait questionnaires. *Heliyon, 7*(2), Article e06243. https://doi.org/10.1016/j.heliyon.2021.e06243

Mental Health Foundation. (2018). May. *Stress: Are we coping?London*. Mental Health Foundation.

Mikkelsen, K., Stojanovska, L., Polenakovic, M., Bosevski, M., & Apostolopoulos, V. (2017). Exercise and mental health. *Maturitas, 106*, 48–56.

Munn, Z., Peters, M. D., Stern, C., Tufanaru, C., McArthur, A., & Aromataris, E. (2018). Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Medical Research Methodology, 18*(1), 1–7. https://bmcmedresmethodol.biomedcentral.com/counter/pdf/10.1186/s12874-018-0481-2.pdf.

Nagel, I. J., Sonnentag, S., & Kuhnel, J. (2015). Motives matter: A diary study on the relationship between job stressors and exercise after work. *International Journal of Stress Management, 22*(4), 346–371. https://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=psyc12&AN=2015-41054-001. https://birmingham-primo.hosted.exlibrisgroup.com/openurl/44BIR/44BIR_Services?sid=OVID:psycdb&id=pmid:&id=doi:10.1037%2Fa0039115&issn=1072-5245&isbn=&volume=22&issue=4&spage=346&pages=346-371&date=2015&title=International+Journal+of+Stress+Management&atitle=Motives+matter%3A+A+diary+study+on+the+relationship+between+job+stressors+and+exercise+after+work.&aulast=Nagel&pid=%3Cauthor%3ENagel%2C+Inga+J%3C%2Fauthor%3E%3CAN%3E2015-41054-001%3C%2FAN%3E%3CDT%3EJournal+Article%3C%2FDT%3E.

Nägel, I. J., Sonnentag, S., & Kühnel, J. (2015). Motives matter: A diary study on the relationship between job stressors and exercise after work. *International Journal of Stress Management, 22*(4), 346.

Naya, C. H., Zink, J., Huh, J., Dunton, G. F., & Belcher, B. R. (2020). Examining the same-day relationship between morning cortisol after awakening, perceived stress in the morning, and physical activity in youth. *Stress: The International Journal on the Biology of Stress*, 1–10. https://doi.org/10.1080/10253890.2020.1804852

Naya, C. H., Zink, J., Huh, J., Dunton, G. F., & Belcher, B. R. (2021). Examining the same-day relationship between morning cortisol after awakening, perceived stress in the morning, and physical activity in youth. *Stress: The International Journal on the Biology of Stress, 24*(3), 338–347. https://www.tandfonline.com/doi/full/10.1080/10253890.2020.1804852.

Niermann, C. Y., Herrmann, C., von Haaren, B., van Kann, D., & Woll, A. (2016). Affect and subsequent physical activity: An ambulatory assessment study examining the affect-activity association in a real-life context. *Frontiers in Psychology, 7*, 677.

Park, Petrunoff, N. A., Wang, N. X., van Dam, R. M., Sia, A., Tan, C. S., & Muller-Riemenschneider, F. (2022). Daily park use, physical activity, and psychological stress: A study using smartphone-based ecological momentary assessment amongst a multi-ethnic Asian cohort. *Mental Health and Physical Activity, 22*, Article 100440 (no pagination) https://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=emexb&AN=2016608229 https://birmingham-primo.hosted.exlibrisgroup.com/openurl/44BIR/44BIR_Services?sid=OVID:embase&id=pmid:&id=doi:10.1016%2Fj.mhpa.2022.100440&issn=1755-2966&isbn=&volume=22&issue=&spage=100440&pages=&date=2022&title=Mental+Health+and+Physical+Activity&atitle=Daily+park+use%2C+physical+activity%2C+and+psychological+stress%3A+A+study+using+smartphone-based+ecological+momentary+assessment+amongst+a+multi-ethnic+Asian+cohort&aulast=Park&pid=%3Cauthor%3EPark+S.H.%3C%2Fauthor%3E%3CAN%3E2016608229%3C%2FAN%3E%3CDT%3EArticle%3C%2FDT%3E.

Parrish, B. P., Cohen, L. H., & Laurenceau, J.-P. (2011). Prospective relationship between negative affective reactivity to daily stress and depressive symptoms. *Journal of Social and Clinical Psychology, 30*(3), 270.

Payne, N., Jones, F., & Harris, P. R. (2010). A daily diary investigation of the impact of work stress on exercise intention realisation: Can planning overcome the disruptive influence of work? *Psychology and Health, 25*(1), 111–129. https://www.tandfonline.com/doi/full/10.1080/08870440903337622.

Peters, M. D., Godfrey, C. M., Khalil, H., McInerney, P., Parker, D., & Soares, C. B. (2015). Guidance for conducting systematic scoping reviews. *JBI Evidence Implementation, 13*(3), 141–146.

Pinto, B. M., Kindred, M. D., Dunsiger, S. I., & Williams, D. M. (2020). Sedentary behavior among breast cancer survivors: A longitudinal study using ecological momentary assessments. *Journal of Cancer Survivorship*, 1–8.

Sala, M., Brosof, L. C., Rosenfield, D., Fernandez, K. C., & Levinson, C. A. (2017). Stress is associated with exercise differently among individuals with higher and lower eating disorder symptoms: An ecological momentary assessment study. *International Journal of Eating Disorders, 50*(12), 1413–1420. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5761745/pdf/nihms929420.pdf.

Schultchen, D.-.-R., Mittl, J., Weh, T., Smyth, T. R. M., Blechert, J. M., & Pollatos, O. (2019a). Bidirectional relationship of stress and affect with physical activity and healthy eating. *British Journal of Health Psychology, 24*(2), 315–333. https://doi.org/10.1111/bjhp.12355

Schultchen, Reichenberger, J., Mittl, T., Weh, T. R. M., Smyth, J. M., Blechert, J., & Pollatos, O. (2019b). Bidirectional relationship of stress and affect with physical activity and healthy eating [Research Support, Non-U.S. Gov't]. *British Journal Of Health Psychology, 24*(2), 315–333. https://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=med16&AN=30672069. https://birmingham-primo.hosted.exlibrisgroup.com/openurl/44BIR/44BIR_Services?sid=OVID:medline&id=pmid:30672069&id=doi:10.1111%2Fbjhp.12355&issn=1359-107X&isbn=&volume=24&issue=2&spage=315&pages=315-333&date=2019&title=British+Journal+of+Health+Psychology&atitle=Bidirectional+relationship+of+stress+and+affect+with+physical+activity+and+healthy+eating.&aulast=Schultchen&pid=%3Cauthor%3ESchultchen+D%3C%2Fauthor%3E%3CAN%3E30672069%3C%2FAN%3E%3CDT%3EJournal+Article%3C%2FDT%3E.

Segerstrom, S. C., & O'Connor, D. B. (2012). Stress, health and illness: Four challenges for the future. *Psychology and Health, 27*(2), 128–140.

Shang, B., Duan, Y., Huang, W. Y., & Brehm, W. (2018). Fluctuation–a common but neglected pattern of physical activity behaviour: An exploratory review of studies in recent 20 years. *European Journal of Sport Science, 18*(2), 266–278. https://www.tandfonline.com/doi/full/10.1080/17461391.2017.1417486.

Shiffman, S., Stone, A. A., & Hufford, M. R. (2008). Ecological momentary assessment. *Annual Review of Clinical Psychology, 4*, 1–32. https://www.annualreviews.org/doi/pdf/10.1146/annurev.clinpsy.3.022806.091415.

Smith, K. E., O'Connor, S. M., Mason, T. B., Wang, S., Dzubur, E., Crosby, R. D., Wonderlich, S. A., Salvy, S. J., Feda, D. M., & Roemmich, J. N. (2021). Associations between objective physical activity and emotional eating among adiposity-discordant siblings using ecological momentary assessment and accelerometers. *Pediatric obesity, 16*(3), Article e12720. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8086815/pdf/nihms-1693843.pdf.

Song, H., Fang, F., Arnberg, F. K., Mataix-Cols, D., de la Cruz, L. F., Almqvist, C., Fall, K., Lichtenstein, P., Thorgeirsson, G., & Valdimarsdóttir, U. A. (2019). *Stress related disorders and risk of cardiovascular disease: Population based, sibling controlled cohort study* (p. 365). bmj.

van Steenbergen, H., de Bruijn, E. R., van Duijvenvoorde, A. C., & van Harmelen, A.-L. (2021). How positive affect buffers stress responses. *Current Opinion in Behavioral Sciences, 39*, 153–160.

Strahler, J., Nater, U. M., & Skoluda, N. (2020). Associations between health behaviors and factors on markers of healthy psychological and physiological functioning: A daily diary study. *Annals of Behavioral Medicine, 54*(1), 22–35. https://watermark.silverchair.com/kaz018.pdf?token=AQECAHi208BE49Ooan9kkhW_Ercy7Dm3ZL_9Cf3qfKAc485ysgAAAtYwggLSBgkqhkiG9w0BBwagggLDMIICvwIBADCCArgGCSqGSIb3DQEHATAeBglghkgBZQMEAS4wEQQM0CW1PueZbmg9dRUAAgEQgIICifsPfhLi75gQBc5qX1X5quB1qytwIa-UseH6_cVblfMKzxea2NtLIiFhuipwP07YN7pgtsIhouwaYQYTiqOry4x3xzDiYW-vt4kzeysZaRihZ-1SVp-_QGIS_eGeto74x-AA4V9mbRBGUSj6WzzuYV9hZz-q_YrPjsOICI64TXeI2HGeHL-dL7Ob-3RiazlS8NCc2IRmRNq3BEjQuR_sICYgez8CFD-5tfBvRazIGqMgsaiBLrTo2jBzqur9NB2Npl-LncAnm_XqYiRfax1gdptaRPiBnR9HvNO9-3K2boOpb9mg3jdvfFtZqYx2HQj_S3k5sSR6TIwTKflU0r8epWPG5wtHHqAjkkk0lkX4W4udKokUc44HhpcWstJDNq7uj4iNYOmSstumWdpTb_2dywpCaXe1107RETh3gWrhHmvN72Hfaop21OVojHOYZW7c6_S0UP1kzO1f3z86aOUsnf4CrN-u3ZoqBrCu-mRvfKRiiBkk0kNVNfTj5thA3tDySuVqVBtpn6RthZypDhVH9fNGA4O9PxA4uIDHvmgna1lt5K1K_I9XWijfOoHg1NT0-fp-VZnqVA7fJ0Wh3-ZrEni5XqEPB3N3y3QJGY93vL1hjcYNu_FkvtUaCca2h5Uyq3c5ufLec8KvGPw4Sqgv_uJK-ZHTJ83azoxf4vM9eqS-LY7g9anGTrd8taJEYavw8_lLBhsNBPKt9twBI_WKwwGReVsVQPZCkheGVTjm-gKA8wLCbZ2oYm9SClayjCS6-XCyX6lXIZolIAwMLoHRn9xIVHavG5KEiwDl4x9KtdE_SqxVxbsaii2bH-T2z4ZAb0a6Zn0JHhqMD5YxdCgbwGCKJWWK9cAKg18.

Stults-Kolehmainen, M. A., & Sinha, R. (2014). The effects of stress on physical activity and exercise. *Sports Medicine, 44*(1), 81–121.

Teychenne, M., Stephens, L. D., Costigan, S. A., Olstad, D. L., Stubbs, B., & Turner, A. I. (2019). The association between sedentary behaviour and indicators of stress: A systematic review. *BMC Public Health, 19*(1), 1–15. https://link.springer.com/article/10.1186%2Fs12889-019-7587-2.

Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K. K., Colquhoun, H., Levac, D., Moher, D., Peters, M. D., Horsley, T., & Weeks, L. (2018). PRISMA extension for scoping reviews

(PRISMA-ScR): Checklist and explanation. *Annals of Internal Medicine, 169*(7), 467–473.

Wipfli, B. M., Rethorst, C. D., & Landers, D. M. (2008). The anxiolytic effects of exercise: A meta-analysis of randomized trials and dose–response analysis. *Journal of Sport & Exercise Psychology, 30*(4), 392–410.

Zawadzki, M. J., Smyth, J. M., & Costigan, H. J. (2015). Real-time associations between engaging in leisure and daily health and well-being. *Annals of Behavioral Medicine, 49*(4), 605–615. https://watermark.silverchair.com/12160_2015_article_9694.pdf?token=AQECAHi208BE49Ooan9kkhW_Ercy7Dm3ZL_9Cf3qfKAc485ysgAAAu8wggLrBgkqhkiG9w0BBwagggLcMIIC2AIBADCCAtEGCSqGSIb3DQEHATAeBglghkgBZQMEAS4wEQQMS7nXYKxx2loEH_hvAgEQgIICoiGG_33sGKE7D1j7xF3gQCTC_BMFe83k5xc59E9gfaWTE-TQwvhXvFam_rJ64lrWS1PUc0zGjJoWsDx9za4hverbd9k0cCUoLsqfOG7_GE1lK1Xb0mZhYeCxefKb477fBhNpKOH2wyHZYmIwNfbh1gvQUPIzlh2qP_VOdMD-OR2GyFo123k61s5QbmMxDnj6DcPOhjs8thUpLgmu3yhKCgsJy7myB3_DbSKKem4KlG-OfRK9djekzlFJsSBUbT1ZFryZKrZ-BQIPw7VZ7yw42gf2NZHaNr5t_ju6zWWOeQq1vpv8NouYMu_6cKJE0szlIY587mwPgQSuD_y652Lrw7ZSKCuRNwdhVcdeKsnsMvnhiwPztL-BIrwKQ9D_szGuCFXnVDsdyUoPFYD4wAC74-_ve1bJ4Be_IT1ljzufj0jktuJY9cQRvS_s3xgz8fcQ7CuXA9qtjopRzK7cb7POONnsoVNpBQK6PilEfdGgwbLJZgJEW8si2ARjOMx04Pd5y1cyDKbsaezCnNmqIxZoy29Ev70GncOcvDmmSfvlOC3fR49BCi7D5qg6-zPaGCRboRMX6Q1Ft2y4G9-hYSG0OyCx2kZ6E6BFS3OghXLYa_P6Wrq9FZ4X0qtO9iiu878XhQIA2bGEtpzM_fkxGsAA0917cfcScVPHhFMnYVoMfXtYy6QSoRfZNnlkC5P8MEUHg8yucCJnC7FuRDuftgQoDmNattkk0-PkOm6wxPFAzQMeKcXeygTiSm5c5CYTFcL2a3h0YoQhLfCU34bFCfZkn2mcRynIGbG-QL0NNZ84qQqlidrsZusG1Q4ELb9365M91JJ6epvPChAlrcO0D8yRV-7y1QEZsCK7rAtYoISxUI-7b-C-vvBQ0OZSI6dpjWp2MayR.

Zenk, S. N., Horoi, I., Jones, K. K., Finnegan, L., Corte, C., Riley, B., & Wilbur, J. (2017). Environmental and personal correlates of physical activity and sedentary behavior in african American women: An ecological momentary assessment study. *Women & Health, 57*(4), 446–462.