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Participants' Compliance with Wearing Physical Activity Trackers: The Role of Menstrual Cycle-Related Symptom Distress

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Abstract

In studies using physical activity trackers (PATs) to self-track, high compliance rates are aimed for in order to ensure sufficient data quality and quantity. Therefore, knowledge about the factors influencing compliance (most commonly operationalized through tracker wear time) is crucial for planning and carrying out research cost- and resource-effectively. The present thesis investigated the presence of menstrual cycle-related symptoms and their intensity, measured indirectly via the *Menstrual Distress Questionnaire*, as a potential influencing factor. Additionally, the role of burden in this context was investigated. From August to December 2025, 48 menstruating individuals, who did not use hormonal contraception, were recruited to wear either an Oura 4 tracker (ring tracker) or a Movisens Move 4 tracker (belt-worn tracker) over the course of one menstrual cycle. During this time period, participants reported their perceived burden of wearing the respective tracker daily, (non-)wear time was an outcome of both PATs. The relationship between symptom distress and burden could not be modelled adequately, neither through a mediation of distress via burden, nor through a moderation of distress on burden. Surprisingly, though, higher retrospective menstrual and premenstrual distress was associated with higher compliance rates during the respective study periods. The possible influence of personality traits as well as motivation through interest in the topic and being affected personally are discussed as possible reasons for these outcomes.

Zusammenfassung

Hohe Adhärenz-Raten sind für Studien, die physische Aktivitätstracker zum *Self-Tracking* verwenden, essentiell, um eine ausreichende Datenquantität und -qualität sicherzustellen. Wissen über mögliche Einflussfaktoren auf die Adhärenz (meist über die Tragezeit der Tracker operationalisiert) ist aus diesem Grund zentral für die kosten- und ressourcenschonende Planung und Durchführung solcher Studien. Die vorliegende Arbeit untersuchte das Auftreten sowie die Intensität von Symptomen im Zusammenhang mit dem Menstruationszyklus, welche indirekt über den *Menstrual Distress Questionnaire* erhoben wurden, als einen möglichen solchen Einflussfaktor. Zudem wurde die Rolle der Tragebelastung in diesem Kontext untersucht. Von August bis Dezember 2025 wurden 48 menstruierende Personen, welche nicht hormonell verhüteten, rekrutiert, um über einen gesamten Menstruationszyklus entweder einen Oura 4 Tracker (Ring-Tracker) oder einen Movisens Move 4 Tracker (an einem Gürtel getragen) zu tragen. Über diesen Zeitraum berichteten die Teilnehmenden täglich ihre Tragebelastung, die Tragedauer wurde mithilfe der Tracker erhoben. Das Verhältnis zwischen *symptom distress* und der Tragebelastung konnte nicht passend modelliert werden, weder die Tragebelastung als Mediator von *symptom distress*, noch dieser als Moderator der Tragebelastung. Überraschenderweise zeigte sich allerdings ein Zusammenhang zwischen höheren retrospektiven *distress*-Werten für prämenstruelle und menstruelle Symptome sowie höherer Adhärenz in den entsprechenden Studienphasen. Als mögliche Gründe für diese Ergebnisse werden Persönlichkeitsmerkmale wie auch durch Interesse an dem Thema und persönliche Betroffenheit bedingte Motivation diskutiert.

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Theoretical Background

Physical Activity Research

The Need for Physical Activity Interventions

Researching behaviors that are beneficial to our health and how these can be supported in everyday life is one of the main objectives of Health Psychology (Brinkmann, 2021). Physical activity (PA) is among the most prominent and influential of the related behaviors and, considering some of the data provided by the World Health Organization (WHO, 2018), it becomes evident why efforts to promote physical activity among the general population are highly necessary: Not only is a lack of physical activity among the leading causes of death worldwide, 23%, almost a quarter of the adult population, do not meet the recommended minimum level of physical activity. An increased risk of cardiovascular disease and cancer as well as adverse mental health outcomes are only some of the possible consequences associated with this deficit (Brinkmann, 2021).

A Successful Physical Activity Intervention

This raises the question how engagement in physical activity can be promoted successfully. Göhner and Fuchs (2007) identified 3 important aspects of interventions targeting physical activity that are commonly disregarded in practice: a sound theoretical base for the implemented measures as well as their standardized application and documentation.

An exemplary intervention that fulfills these criteria, the group program Lifestyle-Integrated Physical Exercise (Lebensstil-Integrierte Sportliche Aktivität, MoVo-LISA), was created by Dr. Reinhard Fuchs. In line with the *Motivation Volition Concept* (Motivations-Volitions-Konzept, MoVo-Konzept), the central assumption is that, in order to change their health behaviors, people need assistance with volitional processes, the willful base to see changes through (Göhner & Fuchs, 2007). Otherwise, their motivation alone, the eagerness to change certain behaviors, would oftentimes be insufficient. This phenomenon is known as the *Intention-Behavior Gap* in Health Psychology (Faries, 2016). The MoVo-LISA intervention consists of two group sessions for groups of 6 participants and one individual session, targeting adult individuals with substandard physical exercise (Fuchs et al., 2008).

During the first group session, participants are asked to recall their previous experience with physical exercise and to focus on the positive aspects that come to mind. They also explore the question why they are partaking in this intervention as a way to ultimately collect their individual health goals. As opposed to behavioral goals, like going for a short walk every day, examples for health goals would be the improvement of one's

physical capacity or pain reduction. This is followed by brainstorming on possible exercise ideas, one of which should be selected and turned into an exercise plan until the individual session. When creating their exercise plan, participants need to make sure the exercise they choose fulfills the criteria of goodness of fit (*Does this physical exercise match my interests?*), practicability (*Do I have the time and financial resources for this physical exercise?*), specification (*What would I like to do, how, where, when and with whom?*) as well as effectiveness (*How would I benefit from this physical exercise?*).

The individual session serves the purpose of receiving feedback on the exercise plan, whether all the criteria are met and whether it is prepared specifically enough to be implemented in everyday life.

Ultimately, in the second group session, obstacles during the realization of the exercise plan are collected, ideally covering a broad spectrum of possibilities. Importantly, strategies to overcome said obstacles are gathered right after. The last part of the second group session comprises the finalization of the participants' individual exercise plans. Over the course of the following 6 weeks, they are asked to adhere to their exercise plans with the option, though, to change some aspects of the plans if necessary. Additionally, they need to keep track of what estimated percentage of the plans they have realized every week. Once the 6 weeks have passed, every participant receives a phone call to go over their experience and to identify any additional necessary changes to their exercise plan.

In the study conducted by Fuchs et al. (2008), MoVo-LISA successfully improved the participants' physical exercise habits, with lasting changes even 12 months after the intervention: Among the 220 participants, 50% of the intervention group reported at least 60 minutes of physical exercise per week in comparison to 33% of the control group, underlining its success.

Physical Activity Assessment

In order to foster the development and improvement of successful physical activity interventions like MoVo-LISA, ongoing research in Health Psychology is necessary. Commonly, everyday physical activity is measured through subjective self-report measures like questionnaires or diaries, objective technological devices or a combination of both (McClung et al., 2018), with recent research focusing on the use of technological devices (Das et al., 2022). Notably, though, neither subjective nor objective measures of physical activity are free of limitations: The former go hand in hand with the issue of remembering events differently from how they actually took place (known as *recall bias*), the

overestimation of the amount of PA performed, adjustments to better align with general expectations (known as the effect of *social desirability*) as well as with the misinterpretation of questions (Das et al., 2022). In comparison, the latter face the limitations of reduced convenience, heightened costs and, oftentimes, a lack of contextual information regarding the data.

Physical Activity Trackers

Especially in studies monitoring physical activity over longer periods of time and/or differentiating between certain types of PA that might be hard to categorize only using introspection (moderate versus vigorous PA, for example) physical activity trackers (PATs) provide reliable data and constitute the measure of choice. PATs are characterized by their wearability, enabling users to carry them on their wrist, for example, while otherwise going about their day normally (Chan et al., 2022). Depending on the sensors such a device is equipped with, it measures different kinds of biometric data, like step count, skin temperature or pulse. This data is either saved on the device itself or on external servers owned by the respective company, available to be downloaded from there. In the last decade, PATs have been used exponentially for research purposes. Because of their rise in popularity regarding research, it is important to ensure they can be used optimally, making meta-research on how to apply them properly necessary.

Anytime physical activity trackers are used in research, enough wear time is critical for sufficient data quality and quantity. The most common cutoff-criterion for sufficient wear time is 10 hours per day (Chan et al., 2022). In an effort to capture as much valuable wear time as possible, factors influencing the compliance with wearing a PAT are studied. Knowledge about these factors can be helpful for future studies in a multitude of ways, for example by choosing incentives associated with higher compliance rates (Faust et al., 2017; Harari et al., 2017; Lee et al., 2013): Depending on the sample, some incentives, like monetary rewards or course credits, might be more successful than others. Access to information like this ahead of time is likely to help save researchers' energy and resources considerably.

Factors Influencing Compliance with Wearing PATs

In the existing literature, factors influencing participants' compliance with wearing physical activity trackers include participant characteristics as well as characteristics regarding the device: Martinez and colleagues (2021), for one, looked at participants' age in relation to their compliance with wearing a smart wristband and found a positive association

between the two. Older participants were more compliant than younger ones, once again showing the tendency also present in most other studies using belt-worn (Evenson et al., 2015; Lee et al., 2013; Troiano et al., 2008) and clip-on (Hermsen et al., 2017) physical activity trackers. In contrast, Harari and colleagues (2017) reported that participants who were younger in age were more compliant. This finding might have been due to the tracking device used for this, though, as participants used their smartphones to do so.

This would fit with the evidence for the influence of the type of physical activity tracker used on compliance. Lazar and colleagues (2015) mentioned curiosity about one's personal data, especially in the beginning, as a motivator to wear PATs. Since they provided money for participants to choose their own tracking devices, they were able to make this comparison relying solely on their sample.

Another aspect, which is relevant in both the context of differences between PAT types and participants' personal preferences, is the perceived comfort when wearing the device. The level of comfort differs, for example, between belt-worn trackers and rings (Brakenridge et al., 2018; Huberty et al., 2015; Peterson et al., 2023). Furthermore, comfort has been found to exert one of the most important influences on participants' compliance, regardless of whether they wore belt-worn trackers (Brakenridge et al., 2018), arm-worn trackers (Huberty et al., 2015), smart watches, smart rings, smart bracelets (Peterson et al., 2023), wristbands (Schrager et al., 2017) or clip-on trackers (Shish et al., 2015).

A highly important factor, which might be less static and more interconnected with other relevant aspects than the other factors listed, is forgetfulness. Forgetting to wear the PAT and/or to put it back on after it had to be taken off is one of the most frequently reported reasons for impeded compliance, as mentioned by Chan et al. (2022), for example.

Lastly, the perceived device aesthetics have also been reported to be relevant in the context of compliance. There have been complaints of belt-worn trackers being hard to wear with clothing, especially for women (Brakenridge et al., 2018) as well as complaints about smart rings being too bulky and looking like men's jewelry (Peterson et al., 2023), for example. Beyond that, the fashion (Schrager et al., 2017) and aesthetics (Shih et al., 2015) of wristbands and clip-on trackers have been reported as facets that impede tracker usage.

Taken together, factors that have been found to impact participants' compliance with wearing different kinds of activity trackers include participants' age, the type of tracker used and forgetfulness as well as the perceived comfort and aesthetics of the respective device.

Using PATs for Research on Menstruating Individuals

The Underrepresentation of Menstruating Individuals

Another potentially influencing factor, which up to this point has not received attention, is constituted by menstrual cycle-related symptoms and their intensity. Considering the history of people with female reproductive organs – the largest part of which is made up by women – in research, this is not surprising. In the fields of health and medical research, in clinical trials, for example, there has been a historical underrepresentation of women, resulting in cis men's bodies as the norm (Mirin, 2021; Smith, 2023). One of the most recent examples for this imbalance is the first publication of a complete three-dimensional model of the neuroanatomy of the clitoris (Lee et al., 2026). While this was only published this year, in 2026, an equivalent model of the neuroanatomy of the penis, on the other hand, has already been accessible for the last 28 years (Yang & Bradley, 1998).

Another prominent example of how, still, the distribution of research efforts cannot be considered equal between the biological sexes is exemplified in Smith's (2023) paper: The author portrays an updated version of Arthur Mirin's (2021) analysis of research funding supplied by the US National Institutes of Health (NIH) and the burden (the resulting number of deaths and disabilities) of diseases that primarily affect women or men. A comparison between the diseases that cause the greatest burden and the ones that receive the most funding demonstrates a lack of correlation between the two. Precisely, almost all of the diseases which primarily affect women (e.g., migraines) are underfunded in relation to the burden they cause. Meanwhile, the diseases that primarily affect men (e.g., substance misuse) receive disproportionately large amounts of funding. This overview emphasizes the ongoing need to think beyond the biologically male body as representative of the average patient and study participant, as this is not the case.

However, this need alone does not constitute a sufficient theoretical background to study menstrual cycle-related symptoms and their intensity as a possible influencing factor of compliance in studies using physical activity trackers. Additional relevant information emphasizing the importance of menstrual cycle-related symptoms in this context is presented in the sections *The Possible Direct Influence of Symptoms on Compliance* and *The Possible Indirect Influence of Symptoms on Compliance*.

The Menstrual Cycle and Related Symptoms

The menstrual cycle is a hormonally regulated physiological occurrence preparing the body for a possible pregnancy and usually affects biologically female individuals, starting

with menarche and ending with menopause. It lasts 28 days on average and there are multiple ways to divide it into phases: The simplest division is the one into the follicular phase – starting on the first day of menstrual bleeding – and the luteal phase – starting after ovulation (Reed & Carr, 2018). The vast majority of people who menstruate experience at least some related symptoms (Schoep et al., 2019). In the context of studying these, a division into a menstrual phase (defined through the presence of menstrual bleeding), a premenstrual phase (defined as the week prior to menstrual onset) and an intermenstrual phase (defined as the days that are neither menstrual nor premenstrual) is useful, since menstrual cycle-related symptoms reportedly most often occur in and differ between the menstrual and premenstrual phase (Vannuccini et al., 2021). Notably, though, this does not imply the under-researched intermenstrual phase (Volpi & König, 2025) is any less relevant than the other two.

Since there is a multitude of different menstrual-cycle related symptoms, grouping them into clusters can be helpful. Volpi and König (2025), for example, differentiated between pain symptoms (e.g., lower abdominal pain), gastrointestinal symptoms (e.g., nausea), symptoms of discomfort (e.g., swelling), psychic and cognitive symptoms (e.g., sadness) as well as physiological symptoms (e.g., insomnia).

The Possible Direct Influence of Symptoms on Compliance

Menstrual symptoms in general have been found to interfere with daily tasks, sometimes even preventing them entirely. Schoep and colleagues (2019) conducted an online study on over 42.000 women, of which 38.4% stated that (while menstruating) they carry out fewer activities than normally or are even incapable of doing anything. The authors did not elaborate further on possible underlying mechanisms. Since, among others, the symptoms of tiredness and psychological complaints were collected in the online survey, though, the underlying mechanisms might not solely be physical but feature motivational components as well. Should that be the case, it would make a similar effect on study-related tasks, like wearing a PAT, plausible.

Additionally, certain individual symptoms and symptom clusters are likely to affect the amount of time PATs are worn for: Firstly, menstrual pain, especially in its intense form, is associated with an impairment of daily activities (Leon-Larios et al., 2024) and an impacted quality of life, including aspects of work and productivity, as well as functioning in daily life (Amza et al., 2024; Iacovides et al., 2023; Weisberg et al., 2016). Wearing a physical activity tracker is possibly influenced in the same way other daily and work-related tasks are, especially in longitudinal studies.

An important addition in this context is that menstrual cycle-related symptoms are not exclusively present during menstruation and/or the premenstrual cycle phase. Although the intermenstrual cycle phase remains under-researched, there is evidence for the presence of symptoms during this phase, too: ovulation pain, for example (Brott & Le, 2023). A recent study even found a range of symptoms similar to that of the premenstrual and menstrual phase for the intermenstrual phase (Volpi & König, 2025).

Secondly, forgetting to wear the PAT is generally listed as one of the main reasons for a lack of compliance in related studies (Boulard Masson et al., 2016; Brakenridge et al., 2018; Chan et al., 2022; Faust et al., 2017; Schrager et al., 2017; Shih et al., 2015; Zhang et al., 2015). Because there are menstrual cycle-related symptoms closely linked to forgetfulness, like tiredness or impaired concentration (Vannuccini et al., 2021), an effect of these on how long the trackers are worn for is plausible, too. Tiredness is likely to be relevant in this context because of the well-known negative effect of sleep deprivation on cognitive performance, including memory (Ansari et al., 2025; Csipo et al., 2021). An impairment of concentration might be important, since both this and forgetfulness are related to impacted cognitive functions (Bajpai et al., 2025).

Furthermore, the aforementioned pain symptoms might additionally foster forgetfulness, as there are findings on pain impacting attention (Keogh et al., 2014; Veldhuijzen et al., 2006), goal-directed behavior and motivation (Wiech & Tracey, 2013).

In summary, (menstrual) symptoms in general as well as (menstrual) pain, tiredness and impaired concentration are all, but for different reasons, likely to affect participants' compliance with wearing a PAT in menstruating individuals. Therefore, the research gap of whether or not menstrual-cycle related symptoms and their intensity are among the factors influencing participants' compliance in PAT-studies, needs to be addressed.

The Possible Indirect Influence of Symptoms on Compliance

Furthermore, some menstrual cycle-related symptoms could affect participants' compliance indirectly, depending on the physical activity tracker used: The experience of wearing a smart ring might worsen during the presence of joint pain or swelling (Vannuccini et al., 2021), for example, or that of wearing a belt-worn tracker while one experiences abdominal pain or digestive problems. This would certainly affect the perceived comfort of the respective PAT – one of the factors reportedly influencing compliance in related studies (Brakenridge et al., 2018; Lazar et al., 2015; Schrager et al., 2017) – negatively and increase the burden of wearing it. Consequently, it would be plausible that via this path, menstrual

cycle-related symptoms and their intensity affect participants' compliance with wearing a PAT indirectly, too.

The Relation Between Symptoms and Symptom Distress

A measure closely linked to menstrual cycle-related symptoms is *symptom distress*. Based on the concept of *menstrual distress* (Vannuccini et al., 2021), it describes the impact of menstrual cycle-related symptoms on different areas of daily life: how they affect work-related and recreational activities, as well as social relationships and the overall quality of life. Based on prior findings, this measure most likely shows a considerably high correlation with the intensity of the symptoms present.

Dennerstein and colleagues (2010) found that, among their sample of over 4.000 women, premenstrual symptom severity and its effect on activities of daily life (ADL) were highly correlated at $r = 0.77$ (95% CI [0.73, 0.81], $p < .001$). For premenstrual symptom severity, participants were asked to individually answer how intensely (from *mild* to *severe*) they experienced any of the 25 listed symptoms in the last 12 months. To assess the overall effect of premenstrual symptoms on ADL, participants answered whether there was *no* effect or a *mild*, *moderate* or *severe* one on their activities regarding work, school, housekeeping, family, social life, sexuality or free time.

Tanaka and colleagues (2013) reported, using their sample of over 19.000 women, that the severity of menstrual symptoms was related to the size of impact they had on participants' work activities. While, among participants with *very strong* severity of the collected 35 menstrual symptoms, 42.1% reported an impact on their work, this was only the case for 5.9% of participants who reported *moderate and below* severity.

Taken together, these findings suggest a considerable correlation between the severity of premenstrual and menstrual symptoms and their impact on daily activities. Since, during the intermenstrual phase of the cycle, the presence of symptoms is comparable to that of the other two phases (Volpi & König, 2025), the same correlation can be assumed for it, enabling the indirect measurement of menstrual cycle-related symptoms across the whole cycle via symptom distress.

Study Aims

The present thesis is part of the study *Physical Activity and the Menstrual Cycle* led by Lucia Volpi, BA MSc at the University of Vienna's Department of Health Psychology. It aims to assess the roles of symptom distress (representative of menstrual cycle-related symptoms and their intensity) and burden (a concept closely related to perceived tracker

comfort) when wearing physical activity trackers in the context of participants' compliance in studies using PATs to self-track. Through this, the list of influential factors in regard to participants' compliance could be extended by one more factor, menstrual cycle-related symptoms, which, in turn, could be partly explained by the burden of wearing a PAT. Knowledge about this possible effect could be immensely beneficial during the conduct of studies using PATs in menstruating individuals, a population that has been historically underrepresented in health and medical research.

Confirmatory Research Questions

Subsequently, the confirmatory research question (RQ 1), *Is participants' compliance in menstruating individuals affected by their symptom distress over the last 12 months?*, will be investigated. In order to do so, the hypotheses H 1.1: *Higher symptom distress over the last 12 months predicts higher tracker non-wear time* and H 1.2: *The relation between symptom distress over the last 12 months and tracker non-wear time can be, at least partly, explained by the burden of wearing a physical activity tracker*, will be tested.

Exploratory Research Questions

Additionally to the relation between symptom distress, compliance and burden across the entire menstrual cycle, differences regarding this relation in specific cycle phases – namely the menstrual, premenstrual and intermenstrual phase – will be investigated. Possible differences between cycle phases could be due to differences in the type of symptoms and the size of their impact on areas of daily life (Volpi & König, 2025) across these phases. Insight in possible distinctions between them could also inform related research, what level of incentives might be beneficial in which phase, for example, enabling funds to be distributed resourcefully. To investigate this, the exploratory research question (E 2): *Does the burden of wearing a physical activity tracker explain the relation between menstrual/premenstrual/intermenstrual distress over the last 12 months and participants' compliance?* will be covered exploratorily.

To further explore the relation between menstrual cycle-related symptoms or distress, respectively, and burden in the context of compliance, the exploratory research question (E 3): *Does menstrual/premenstrual/intermenstrual distress over the last 12 months affect the strength of the relation between the burden of wearing a physical activity tracker and participants' compliance?* will be investigated exploratorily.

Methods

Sample

Recruitment

Starting in August 2025, naturally cycling and regularly menstruating participants aged 18 years or older were recruited. In the beginning, this was done by distributing study flyers in Vienna and online (via WhatsApp groups, Instagram and Facebook), as well as through word of mouth. By October of 2025, the study was additionally promoted via 2 *Laboratory Administration for Behavioral Science* (LABS) courses for Bachelor and Master psychology students at the University of Vienna. After the completion of the study, participants who took part via LABS received 15 credits, with one credit being equivalent to 15 minutes of work. Those who were recruited outside of LABS received a monetary reward of 30€ instead. Data collection ended in March 2026 but, because of reasons of time, only data collected until December 2025 was included for the present thesis.

Eligibility Criteria

Anyone interested in participating in the study had to complete an online screening questionnaire first, provided via the online survey tool Unipark.

Inclusion criteria comprised being at least 18 years old, reporting an average menstrual cycle length of between 21 and 35 days, as well as the first menses having occurred more than 3 years ago.

Exclusion criteria, on the other hand, included menopausal symptoms like hot flushes, gynaecological conditions like Polycystic Ovarian Syndrome (PCOS) or endocrine conditions like thyroid conditions. Furthermore, participants who had used hormonal contraception except for copper Intrauterine Devices (IUDs) during the 3 menstrual cycles prior, participants who were pregnant, trying to get pregnant and/or had breastfed during the 3 menstrual cycles prior or those who underwent hormonal treatments or planned to do so in the following month were screened out. Lastly, anyone who stated they had experienced lifetime psychiatric history, who took medication altering ovulation, worked shifts, experienced physical movement limitations or participated in other studies measuring physical activity and/or using the app m-Path during the study period, needed to be excluded as well. Aside from the initial screening questionnaire, these eligibility criteria were also checked for every participant in person at the start of the study. Additionally, at the end of the study, participants were asked about any reproductive changes (e.g., pregnancy) during the study period.

Sample size

Due to multiple reasons, a formal power calculation could not be conducted: For one, there is a lack of prior comparable studies that could provide related data, leaving no anchors for possible effect sizes. Besides that, the overarching study was part of a student project and dealt, at times, with a reduced tracker availability due to other ongoing studies, limiting the time and resources available.

The resulting target sample size of 60 participants is in line with the current guidelines for feasibility studies (Eldridge et al., 2016; Orsmond & Cohn, 2015; Teresi et al., 2022). After the enrollment of 40 participants, the rate of drop-outs and data quality were checked. Based on these findings, an iterative estimation of how many additional participants were needed to reach the target sample size of 60 and further collection of data took place.

Design and Procedure

The overarching study *Physical Activity and the Menstrual Cycle*, led by Lucia Volpi, BA MSc at the University of Vienna's Department of Health Psychology (the corresponding preregistration has not been published yet), was an observational study using a between-subjects mixed-methods design. A preregistration of the present thesis had been uploaded to the internal study database of the University of Vienna's Department of Health Psychology before any data analysis was carried out.

After completing the online screening questionnaire, eligible participants were presented with an adapted version of the *Menstrual Distress Questionnaire* (MEDI-Q, Vannuccini et al., 2021). Right after, they were able to pick a convenient time for their enrollment visit via the website TERMINO or the calendar on LABS. Each of the offered slots had either been assigned to the Movisens (Movisens GmbH, 2025) group or the Oura (Oura Health Oy, 2025) group beforehand. The participants were unaware of which physical activity tracker they would use until their enrollment visit and unaware of which other PAT was used in the study until their second appointment.

At their enrollment visit, participants' start-of-study dates and end-of-study dates were determined by their average cycle length, shortest cycle length in the last 6 months and last menstrual onset date. The calculation was based on the recommendations of Schmalenberger et al. (2021) and resulted in participants either starting in their perimenstrual, mid follicular, periovulatory or mid luteal cycle phase. They also received the related materials: a PAT with a corresponding information sheet and an ovulation test kit, including 12 analogue ovulation tests and an information sheet with instructions on how to use them. Moreover, the

participants were instructed to install the study app/s on their phones. Afterwards, they were assisted with the setup: Through the mobile app m-Path, which was used by both tracker groups, a short daily questionnaire (with questions on bleeding, sleep time and burden, among others) as well as reminders for the daily questionnaire and to upload pictures of the ovulation test results were administered. Reminders for the former were set to come in every 30 minutes, starting from the timeslot the participants had picked to answer it and ending at 11:30 a.m. Reminders for the latter were set to come in every 30 minutes as well, starting from the preferred time to upload them and ending up to 180 minutes later or at 8:30 p.m., dependent on which criterion was the first one to apply. Also, participants were able to reach out to the study team via the direct chat on m-Path at any time and vice versa. For example, the study team reached out to inform participants they could stop the ovulation testing, whenever this was the case. On Oura, the app which only the group with Oura trackers used, participants created an account using an assigned study e-mail address and connected to their Oura ring for the first time to enable data synchronization thereafter. During the whole process, participants were encouraged to ask clarifying questions at any time.

The study period was set to participants' individual average cycle lengths. During the respective period, they were asked to wear their physical activity tracker as much as possible (Oura trackers should also be worn overnight), answer the daily questionnaire on m-Path and to test for ovulation on up to 10 corresponding days, as well as to upload pictures of the test results on m-Path. Additionally, they were encouraged to reach out to the study team, either via e-mail or via the direct chat on m-Path, whenever they needed help or further clarification.

After the end of their study period, participants were asked to come back in for a second appointment. During this, they returned the study materials and stayed for an end-of-study interview to better understand their experience with the study and to collect potential feedback for improvement. The interview covered questions about the experience of partaking in the study, questions about non-compliance, about the other tracker (after introducing it) and questions about general feedback. Afterwards, participants were debriefed and asked if they would like a summary of the study results. They also received the compensation of either 15 credits or a transfer of 30€ to their bank account.

Notably, anyone involved in the instruction of participants during the enrollment visit or second appointment had received a protocol of the related procedure beforehand and had taken part in a practice session as well.

Measures and Materials

MEDI-Q

An adapted version of the MEDI-Q by Vannuccini et al. (2021) was used to collect participants' symptom distress over the past 12 months. Symptom distress refers to the impact of menstrual cycle-related symptoms on menstruating individuals' quality of life, recreational and work activities and/or their social relationships. This was used as the independent variable for all research questions and hypotheses except for E 3, for which it was the moderator. For the corresponding exploratory research questions, the MEDI-Q scores B (measuring mean menstrual distress), C (measuring mean premenstrual distress) and D (measuring mean intermenstrual distress), were used. In regard to this, the menstrual phase was defined by the length of the menstrual period, the premenstrual phase as the 7 days prior and the intermenstrual phase as the rest of the menstrual cycle. Following the example of Volpi and König (2025), participants were asked to report the occurrence and impact of 25 menstrual cycle-related symptoms, like lower abdominal pain or irritability, using a 4-point Likert scale ranging from *no distress* to *severe distress* for the impact each symptom caused them over the last 12 months. They gave separate answers for the 3 respective cycle phases, enabling them to report the occurrence of a certain symptom only during the premenstrual phase, for instance. For the premenstrual and intermenstrual phase, for the scores C and D, this happened indirectly, using the answer option *Never had this symptom during the [respective cycle phase]*. Additionally, some items were rephrased to ensure better understanding. For score B, the mean of the 25 items covering menstrual distress was calculated. The same procedure was used for score C and the items regarding premenstrual distress as well as for score D and the items regarding intermenstrual distress.

In the current study, using Cronbach's alpha, the MEDI-Q showed high to excellent internal consistency: $\alpha = 0.81$ (95% CI [0.74, 0.89]) in score B (regarding menstrual distress), $\alpha = 0.95$ (95% CI [0.94, 0.97]) in score C (regarding premenstrual distress) and $\alpha = 0.98$ (95% CI [0.97, 0.99]) in score D (regarding intermenstrual distress).

Measures Collected Via the Screening Questionnaire

As one of the covariates included for all research questions and hypotheses, participants' age was collected at the beginning of the screening questionnaire. For this, the question *What is your age (in years)?* and a free input-field was used.

Measures Collected Via the Daily Questionnaire

The perceived burden of wearing a physical activity tracker was used as the

independent variable for E 3 as well as the mediator for H 1.2 and E 2. In the daily questionnaire, it was collected through the question *If you think of yesterday, how much has wearing your tracker been bothering you?* and a slider from 0-100 and from *not at all* to *extremely*.

Measures Collected Via the End-Of-Study Interview

As another covariate included for all research questions and hypotheses, besides the variable *age* and the tracker type, device aesthetics were utilized. This variable was measured in the end-of-study interview. To do so, participants answered the question *Did the device aesthetic or looks bother you?*. In the cases in which participants did not give a clear "yes" or "no" answer, their answer was coded by the study team: If someone mentioned that the aesthetic was fine and they liked wearing the tracker, for example, their answer was coded as *no* - whereas if someone said it was not "really their style", for example, it was coded as *yes*.

Physical Activity Trackers

2 types of physical activity trackers were used and distributed in equal parts among the sample, the Oura ring 4 tracker (Oura Health Oy, 2025) and the Movisens Move 4 tracker (Movisens GmbH, 2025). Together with their PAT, participants received a corresponding information sheet with instructions for wearing and charging as well as frequently asked questions. The former tracker is a smart ring, which participants of the Oura group were asked to wear on the index, middle or ring finger of their non-dominant hand. The latter is a belt-worn tracker, which participants of the Movisens group were asked to wear, attached to an elastic belt, on their left hip – preferably on top of their clothing, as to avoid skin irritations. Notably, Movisens trackers are not waterproof, so participants were informed to take them off in the shower, for example, in addition to taking them off during nighttime.

For both of these PATs, it is possible to get access to the daily non-wear time, meaning any time the participants technically should have worn their tracker but did not. This was the dependent variable for all research questions and hypotheses, either initially measured in minutes during waking minutes or converted to fit this metric.

Study Apps

The mobile app m-Path was used for the administration of the daily questionnaire as well as for participants to upload pictures of the ovulation test results. Corresponding reminders for the daily questionnaire were set to the participants' preferred time before noon, while reminders to take the ovulation tests were set to the participants' preferred time

between 10 a.m. and 8 p.m. on the respective days.

The mobile app Oura was used for participants of the Oura group. Via this, they synchronized their data collected through wearing the ring with their account on the Oura cloud. It also enabled participants of this group, in contrast to those of the Movisens group, to get insight on their personal data anytime. The personal data provided by Oura included measures of sleep quality (e.g., an overview of the sleep stages), physical activity (e.g., calorie consumption), available energy (e.g., indicators of illness), stress (e.g., stress recovery), heart health (e.g., heart rate) and women's health (e.g., prediction of menstruation) (Oura Health Oy, 2025). Notably, this option was not mentioned by the study team, yet still, participants regularly stated they were interested and had checked it out during the end-of-study interviews.

Documentation of the Measures and Materials

In alignment with the principles of Open Science, the questionnaires and other study materials relevant to this thesis were documented in an internal database of the University of Vienna's Department of Health Psychology. Data files containing all of the variables used for this thesis, a respective codebook, the script used for data preprocessing, the analysis files and the *Results* section were shared on there as well.

Data Cleaning and Preprocessing

Exclusions Post-Data Collection

Participants who reported invalid days of wear time, characterized by less than 10 hours of tracker wear time, for more than half of their observed menstrual cycle and/or who mentioned that their reproductive status had changed (e.g., pregnancy) during the study period were excluded.

At a day-level, any day with a wear time of less than 10 hours was additionally excluded from the analyses.

Data Cleaning, Screening and Missing Data

The statistical requirements for the mediation and moderation analyses were checked before carrying them out (see section *Statistical Analyses*), including checks for outliers. The handling of outliers is described transparently in the section *Results*.

Moreover, if participants failed to report their bedtime and wake-up time on a given day, the missing data was replaced by their average wake-up and bedtime calculated across the entire study period. Similarly, if participants did not report their perceived burden of

wearing the tracker on a given day, the missing data was replaced by their average burden across the entire study period for RQ 1 and, for E 2 and E 3, by their average burden across the respective menstrual cycle phase.

Data Preprocessing

For non-wear time, the Oura ring data was converted from seconds at the day level into minutes during waking minutes.

Regarding the MEDI-Q by Vannuccini et al. (2021), all symptoms a participant did not experience were treated as or recoded to logical missingness: In score B, which covers the menstrual symptom distress, the corresponding questions were not asked. This resulted in the value -77, all of which were excluded. In scores C and D, covering premenstrual and intermenstrual symptom distress, the answer option *Never had this symptom during the [respective cycle phase]* with the value 5 was excluded.

Furthermore, for RQ 1, tracker non-wear time and the perceived burden of wearing a tracker were averaged across the entire study duration. Symptom distress was averaged across the entire study duration as well, using a weighted average since the intermenstrual phase is roughly twice as long as the others. For both E 2 and E 3, tracker non-wear time and the perceived burden of wearing a tracker were split into the 3 menstrual cycle phases before being averaged across each of them: Meaning, for example, if participant A reported that they had had their menstruation from September 1st to September 5th, only the data collected on those days were used for them in the exploratory analyses of the menstrual phase. Values of symptom distress were kept as mean menstrual, premenstrual and intermenstrual distress using the MEDI-Q scores B, C and D.

Regarding the menstrual cycle phases, the menstrual phase was coded as the first day participants reported the presence of bleeding in the daily questionnaire until the first day they did not anymore. The premenstrual phase was coded as the (up to) 7 days prior to menstrual onset and the intermenstrual phase as the remaining number of days which were neither menstrual nor premenstrual.

Additionally, the tracker type – Movisens (Movisens GmbH, 2025) or Oura (Oura Health Oy, 2025) – as well as the perceived device aesthetics (bothersome to the participant or not) were dummy coded before being used as covariates (Movisens = 0, Oura = 1; bothersome = 0, not bothersome = 1). Lastly, the predictor variables symptom distress and perceived burden were mean-centered before being used in the moderation analyses.

Statistical Analyses

In order to conduct the confirmatory mediation analysis in JASP (version 0.96; JASP Team, 2026), regarding RQ 1), path models and the bootstrapping-method for indirect paths were used. The corresponding H 1.1 was assessed using the significance of the simple regression and the direction (positive or negative) of the regression coefficient. The corresponding H 1.2 was assessed via the 95% CIs for the indirect paths and their inclusion of zero, as well as via the direction (positive or negative) of the indirect effect. In the corresponding JASP module (*Structural Equation Modeling*), the default analysis is two-sided.

For the conduct of the exploratory research question E 2, the same procedure as described above was used for the 3 mediation analyses – covering the menstrual, premenstrual and intermenstrual cycle phase – regarding E 2.

For the exploratory research question E 3, a two-sided moderation analysis was employed in JASP. This moderation model was applied to the three menstrual cycle phases separately.

As for inference criteria, the standard criterion of $p < .05$ was used. It was checked, as already mentioned, whether the 95% CIs included zero to determine the results' significance.

For all of the analyses, it was ensured the following statistical requirements (Field, 2018) were met: The assumption of linearity and homoscedasticity were checked visually, using plots for the predicted vs. actual residuals. Almost all of these plots did not show any systematic structures. Those of RQ 1 and E 2 (pre- and intermenstrual phase), all for the path from the mediator to the dependent variable, though, showed funnel-shaped tendencies. Since all mediation analyses were carried out with 1.000 bootstrap repetitions, no further compensatory measures were taken. Beyond that, to address the criterion of no extreme outliers, all analyses with influential cases (which were identified using the default setting of standardized residual > 3) are presented both with the inclusion and exclusion of said cases. The exact numbers of outliers considered for each analysis are listed in Figure 1. The normal distribution of the residuals was evaluated visually, with the use of quantile-quantile plots. For all of the analyses included, these showed no notable deviations. Lastly, checks for multicollinearity were run as well, using the variance inflation factor (VIF). Again, all of the included analyses showed VIF values way below the critical value of 10. Taken together, most of the statistical requirements for the following analyses were fulfilled initially. The issues of funnel-shaped residuals plots and influential cases were addressed through bootstrapping and reporting alternative analysis outcomes.

Deviations from the Preregistration

Deviations Regarding Eligibility Criteria

In the present thesis, the time criterion of the "last 3 menstrual cycles" was used for the criteria of no use of hormonal contraception except for copper IUDs and breastfeeding, whereas in the preregistration the "last 3 months" was used. This deviation came about because of a typing error, the actual phrasing in the screening questionnaire was in line with the present thesis.

Deviations Regarding Descriptive Statistics

Some of the participants had to be excluded for reasons other than those listed in the preregistration. This was the case when not all included covariates were available for participants, when their premenstrual phase could not be identified and when they did not mention any intermenstrual symptoms and therefore no intermenstrual distress. Because of this missing data, they had to be excluded from all analyses in the first case and from the respective analyses of E 2 and E 3 in the other cases.

Deviating from the preregistered plan, participants' gender identity was not mentioned separately in section *Descriptive Statistics*, since 100% of this sample identified as female. The only non-binary participant was excluded, as a sample of $n = 1$ was not sufficient to repeatedly run the analyses and an inclusion of this participant might have distorted the remaining data due to gender effects. Because of anonymity concerns, the descriptive values as well as those necessary for the analyses were not listed for this participant either.

The inclusion of the variable *relative tracker wear time* constitutes another deviation for this section. It was calculated through dividing all eligible days (meaning those with at least 10 hours of wear time), for each participant, by the number of days they took part in the study and averaging these values across the sample. It was reported, in contrast to non-wear time, as a more intuitive measure of how compliant participants were on average. Notably, the relative tracker wear time might have been even higher for some participants than reported. The reason for this are missing values of tracker non-wear time on some days. These are likely to have come about because the trackers had not recorded, either because of an empty battery or because of other technical issues. This was the case for a total of 57 of the overall 1565 days that participants had worn the trackers. All of these were excluded for the analyses but included for the calculation of the relative tracker wear time, as there was no way to check whether and how long the participants had worn the tracker on those days.

Even though it had not been planned to do so, information on the variation of

compliance (using the variable *non-wear time*) as well as of the variation of intermenstrual distress was added, because it was of interest for the interpretation of results.

Deviations Regarding Inferential Statistics

Due to the lack of significance for all investigated mediation and interaction effects, the respective analyses of E 2 and E 3 were not compared through their significance and sizes of the effects afterwards. Moreover, the sizes of the mediation and interaction effects were not estimated using Cohen's benchmarks and simple slopes ($M \pm 1\ SD$) were not used either, for the same reason.

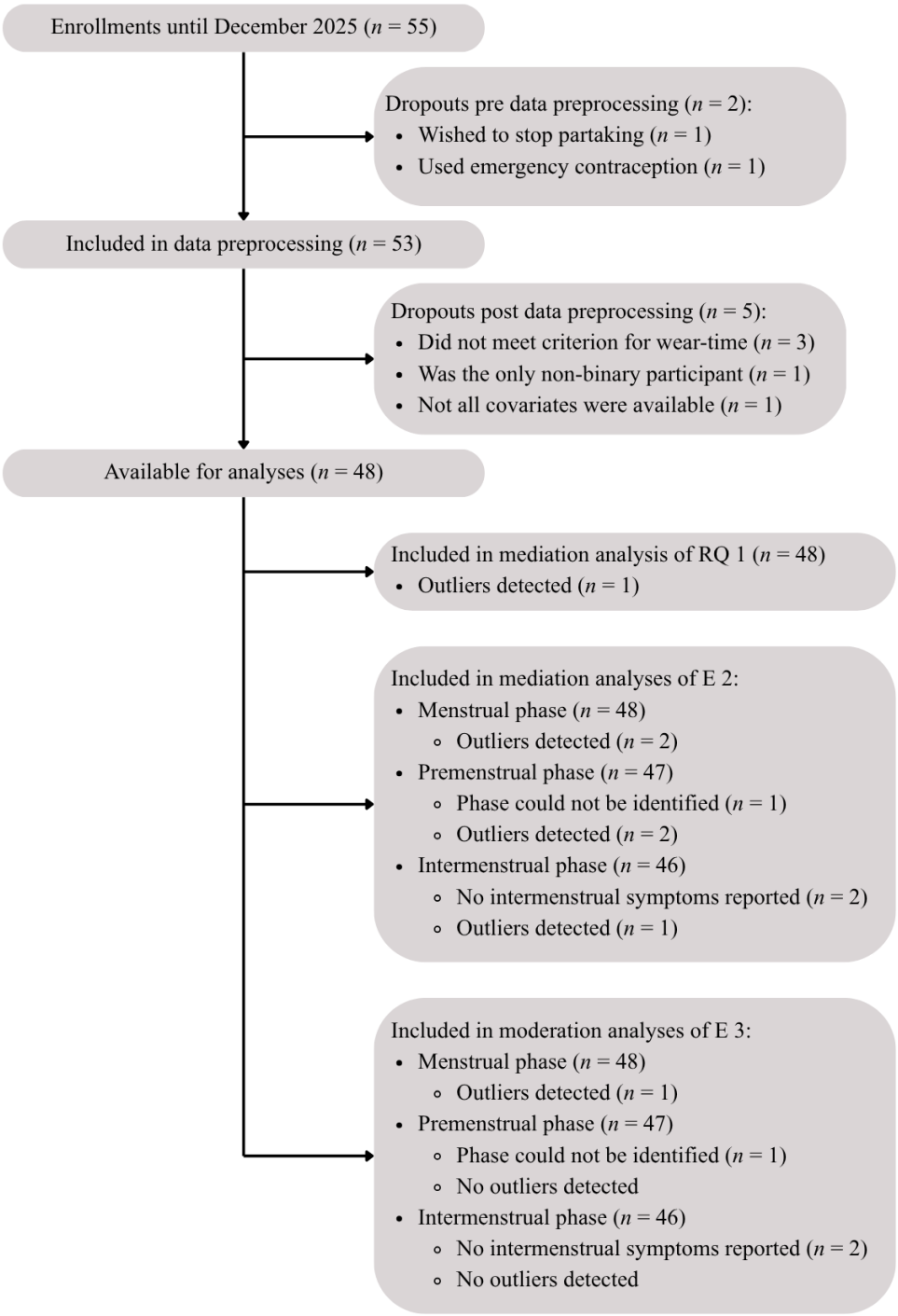
Results

Descriptive Statistics

For the statistical analyses of present thesis, the original participant pool included everyone who took part in the study *Physical Activity and the Menstrual Cycle*, led by Lucia Volpi, BA MSc, from the study start in August 2025 until December 2025. This resulted in 55 participants. As demonstrated in Figure 1, a total of 7 participants had to be excluded and/or dropped out due to different reasons. Out of the 48 remaining participants, only 47 could be included in the E 2 and E 3 analyses regarding the premenstrual phase, since it was not possible to define a premenstrual phase for 1 participant. Furthermore, because 2 other participants did not report any symptoms during the intermenstrual phase, only a total of 46 could be included in the E 2 and E 3 analyses regarding the intermenstrual phase.

Figure 1

Participant Flow



In Table 1, descriptive statistics are provided for the distribution of the (n = 48) participants' level of education, way of recruitment and age as well as their average non-wear times, perceived burden, symptom distress and relative tracker wear times.

Table 1

Descriptive Statistics (n = 48)

Sample characteristics	Percentage (%)	Mean (*M*)	Standard deviation (*SD*)
Level of education			
No vocational training (yet)	39.6	-	-
Apprenticeship	2.1	-	-
Technical/vocational secondary school	14.6	-	-
Technical college	0.0	-	-
University	41.7	-	-
Doctorate	0.0	-	-
Other	2.1	-	-
Way of recruitment			
Via LABS	58.3	-	-
Outside of LABS	41.7	-	-
Age (years)	-	23.3	5.9
Non-wear time (mins)			
Overall	-	74.2	53.7
Menstrual phase	-	79.1	70.9
Premenstrual phase (*n* = 47)	-	74.4	62.7
Intermenstrual phase	-	71.3	52.5
Perceived burden			
Overall	-	13.9	14.1
Menstrual phase	-	13.9	14.3
Premenstrual phase (*n* = 47)	-	15.5	16.9
Intermenstrual phase	-	13.8	15.2
Symptom distress			
Overall (weighted)	-	1.8	0.4
Menstrual phase	-	2.2	0.5
Premenstrual phase	-	1.9	0.5
Intermenstrual phase (*n* = 46)	-	1.7	0.5
Relative tracker wear time	-	0.85	0.14

Note. For $n = 1$ participant, the premenstrual phase could not be identified. Additionally, $n = 2$ participants did not report any intermenstrual symptoms, which is why they are not part of the sample regarding the respective characteristics.

As presented in supplementary Figure A 1, participants' non-wear time across the entire study period ranged from 12 to 212 minutes, with 75% of the values falling between 12 and 110 minutes.

Participants' variation in intermenstrual distress is shown in supplementary Figure A 2. Values ranged from 1 to 3, with 75% of the data falling between 1 and 2.

Inferential Statistics

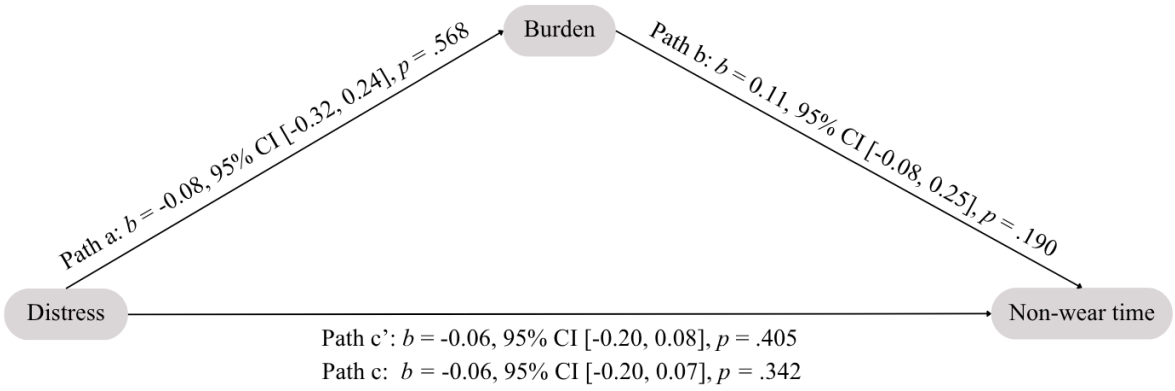
RQ 1: Is participants' compliance in menstruating individuals affected by their symptom distress over the last 12 months?

Since the total effect of symptom distress on non-wear time was neither significant nor positive, as shown in Figure 2, the corresponding H 1.1 (*Higher symptom distress over the last 12 months predicts higher tracker non-wear time*) could not be retained. The same was the case for the corresponding H 1.2 *(The relation between symptom distress over the last 12 months and tracker non-wear time can be, at least partly, explained by the burden of wearing a physical activity tracker*), because the 95% CIs for the indirect paths did include zero and the indirect effect was not positive ($b = -0.01$, 95% CI [-0.07, 0.02]).

This analysis was repeated without extreme outliers, which did not change the outcome for the tested hypotheses, only the values of the direct ($c = -0.05$, $SE = 0.07$, $p = .420$) and indirect ($b = -0.001$, 95% CI [-0.06, 0.02]) paths.

Figure 2

Confirmatory Mediation Analysis (RQ 1)

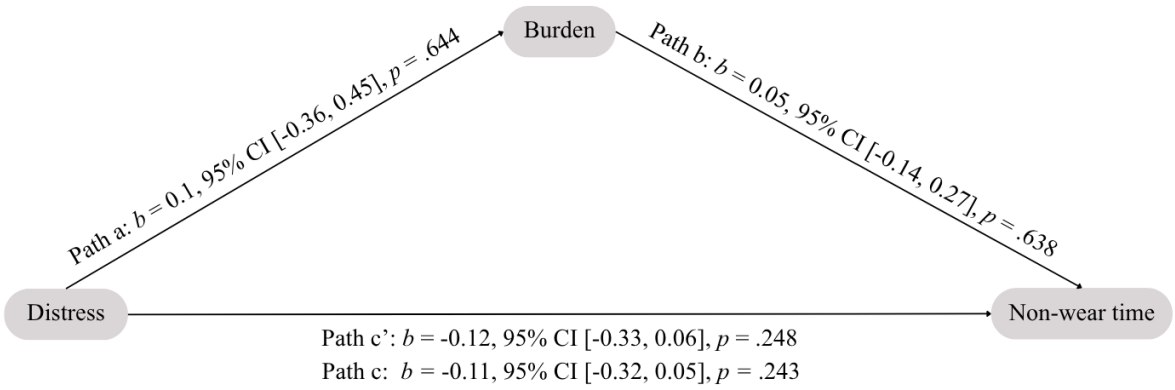


E 2: Does the burden of wearing a physical activity tracker explain the relation between menstrual/premenstrual/intermenstrual distress over the last 12 months and participants' compliance?

Menstrual Phase. As presented in Figure 3, the total effect of menstrual distress on non-wear time was negative and not significant. Its indirect effect via burden (b = 0.01, 95% CI [-0.03, 0.09]) was not significant either. The results' significance did not change when the analysis was repeated without extreme outliers, neither for the direct (c = -0.16, SE = 0.11, p = .132) nor for the indirect path (b = -0.004, 95% CI [-0.10, 0.03]). With the exclusion of extreme outliers, though, both effects were negative.

Figure 3

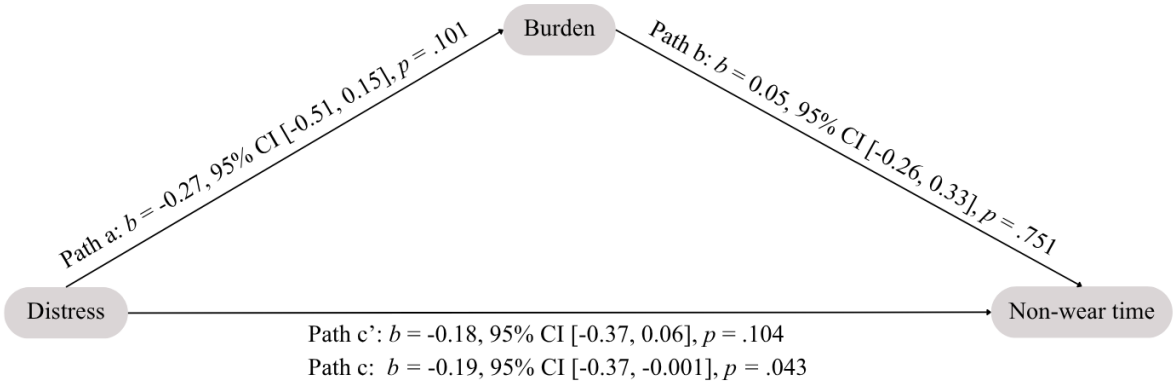
Exploratory Mediation Analysis: Menstrual Phase (E 2)



Premenstrual Phase. While, as presented in Figure 4, the total effect of premenstrual distress on non-wear time was negative and significant, its indirect effect via burden (b = -0.01, 95% CI [-0.14, 0.06]) was not. Notably, this finding changed for the direct path (c = -0.08, SE = 0.10, p = .397) when the analysis was repeated without extreme outliers. For the indirect path (b = -0.01, 95% CI [-0.10, 0.04]), it remained the same.

Figure 4

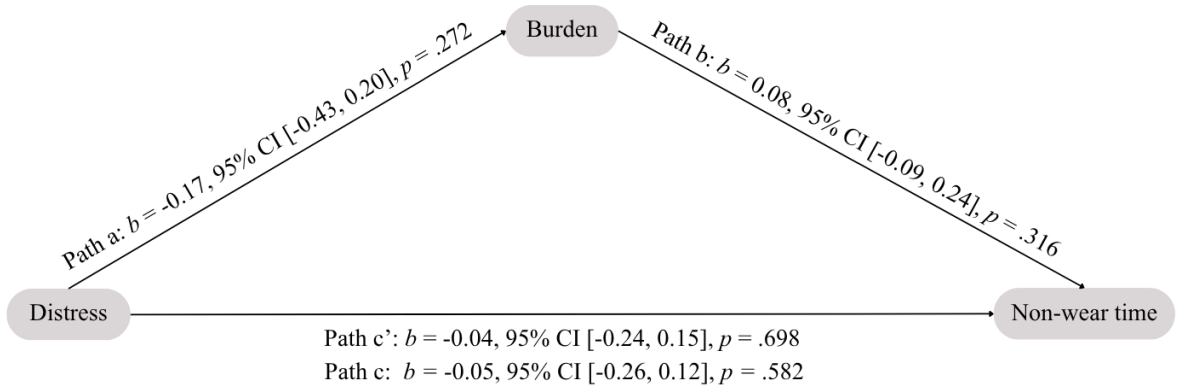
Exploratory Mediation Analysis: Premenstrual Phase (E 2)



Intermenstrual Phase. Both the total effect of intermenstrual distress on non-wear time, as presented in Figure 5, and its indirect effect via burden (b = -0.01, 95% CI [-0.08, 0.01]) were non-significant and negative. This finding did not change when the analysis was repeated without extreme outliers, neither for the direct (c = -0.05, SE = 0.10, p = .637) nor for the indirect path (b = -0.01, 95% CI [-0.11, 0.02]).

Figure 5

Exploratory Mediation Analysis: Intermenstrual Phase (E 2)



E 3: Does menstrual/premenstrual/intermenstrual distress over the last 12 months affect the strength of the relation between the burden of wearing a physical activity tracker and participants' compliance?

Menstrual Phase. The whole interaction model M_2 was significant ($F[17, 30] = 4.03$, $p < .001$, $R^2_{adj} = .52$, $R^2_{Change} = .02$). As mentioned in Table 2, no significant moderation effect of distress on the relation between burden and non-wear time could be found, which is why M_1 is reported: The whole model was significant as well ($F[16, 31] = 4$, $p < .001$, R^2_{adj} =

.51). While the main effect of burden was not significant, that of distress was. This means, as displayed in Figure 6, that the more menstrual distress a participant reported in the MEDI-Q, the more they wore their tracker during the menstrual phase of the study period. When this analysis was repeated with the exclusion of extreme outliers, the findings remained the same. The moderation effect (b = 0.24, SE = 1.12, t = 1.53, p = .137) as well as the main effect of burden (b = 4.82, SE = 25.51, t = 0.83, p = .415) were non-significant, while both M_2 (F[17, 29] = 4.57, p < .001, R^2_{adj} = .57, R^2_{Change} = .02) and M_1 (F[16, 30] = 4.51, p < .001, R^2_{adj} = .55) as well as the main effect of distress (b = -0.40, SE = 20.19, t = -2.78, p = .009) were.

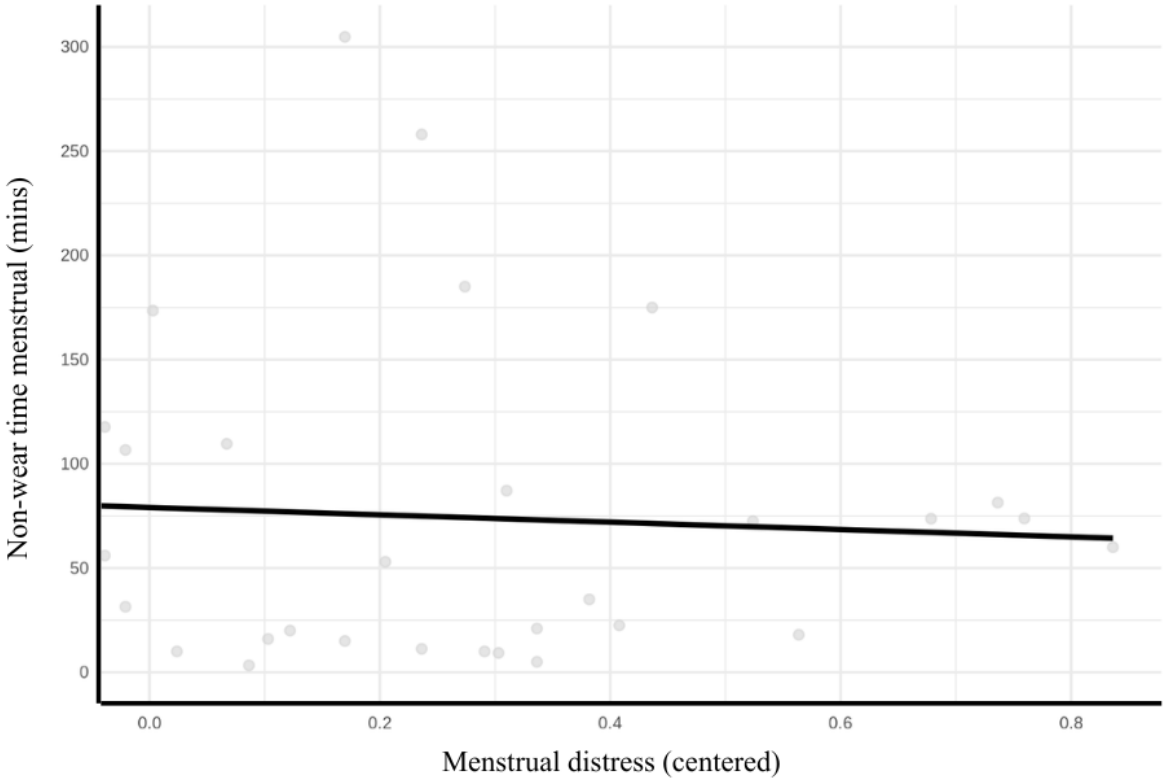
Table 2

Exploratory Moderation Analysis: Menstrual Phase (E 3)

	Unstandardized Coefficient	Standard Error	Standardized Coefficient	*t*	*p*
Interaction effect (M_2)					
Burden * Distress	1.92	1.32	0.24	1.46	.156
Main effects (M_1)					
Burden	20.22	29.96	4.09	0.68	.505
Distress	-61.33	23.65	-0.39	-2.59	.014

Figure 6

Main Effect of Menstrual Distress (E 3)



Premenstrual Phase. The whole interaction model M_2 was significant ($F[17, 29] = 5.33$, $p < .001$, $R^2_{adj} = .62$, $R^2_{Change} = .002$). As presented in Table 3, no significant moderation effect of distress on the relation between burden and non-wear time could be found, which is why M_1 is reported: The whole model was significant as well ($F[16, 30] = 5.81$, $p < .001$, $R^2_{adj} = .63$). While the main effect of burden was not significant either, that of distress was. This means, as displayed in Figure 7, that the more premenstrual distress a participant reported in the MEDI-Q, the more they wore their tracker during the premenstrual phase of the study period. There were no extreme outliers identified in regard to this analysis.

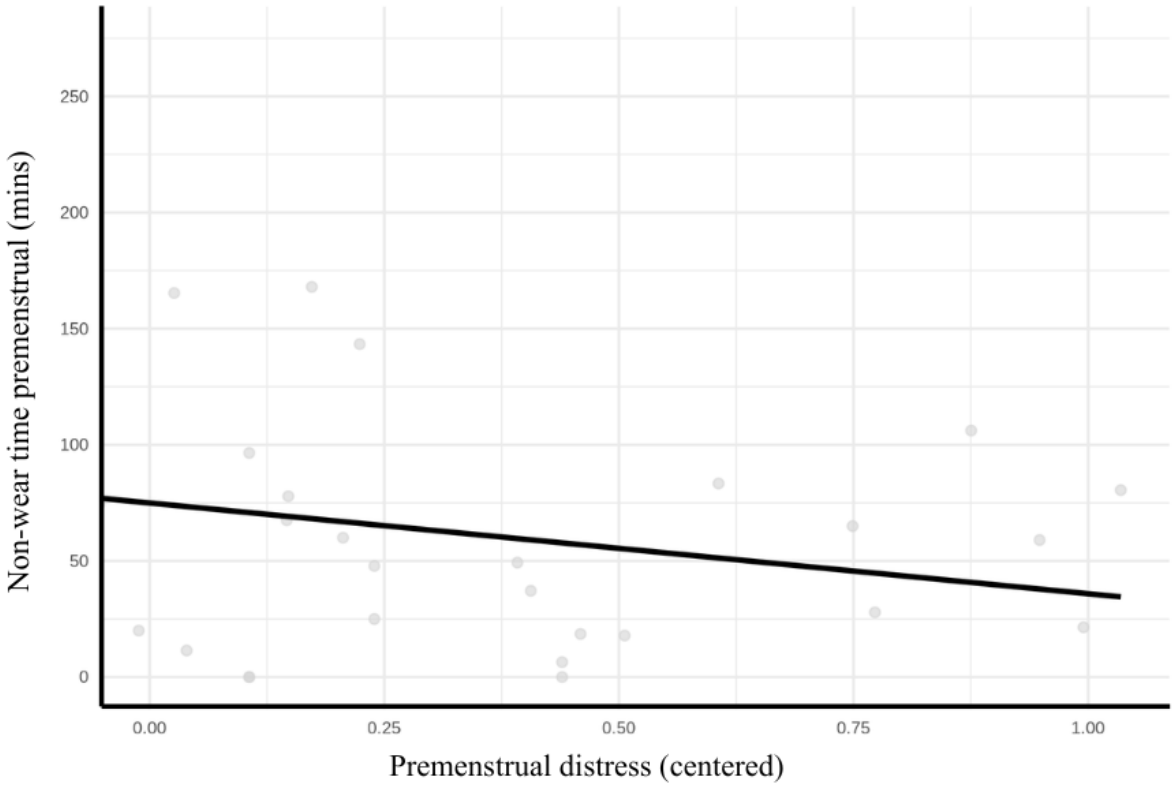
Table 3

Exploratory Moderation Analysis: Premenstrual Phase (E 3)

	Unstandardized Coefficient	Standard Error	Standardized Coefficient	*t*	*p*
Interaction effect (M_2)					
Burden * Distress	0.47	1.06	0.09	0.44	.661
Main effects (M_1)					
Burden	-31.99	19.80	-8.62	-1.62	.117
Distress	-43.72	13.59	-0.36	-3.22	.003

Figure 7

Main Effect of Premenstrual Distress (E 3)



Intermenstrual Phase. The whole interaction model M_2 was significant ($F[17, 28] = 7.36$, $p < .001$, $R^2_{adj} = .71$, $R^2_{Change} = .004$). As presented in Table 4, no significant moderation effect of distress on the relation between burden and non-wear time could be found, which is why M_1 is reported: The whole model was significant as well ($F[16, 29] = 7.87$, $p < .001$, $R^2_{adj} = .71$). Neither the main effect of burden nor that of distress were significant. Also, there were no extreme outliers identified in regard to this analysis.

Table 4

Exploratory Moderation Analysis: Intermenstrual Phase (E 3)

	Unstandardized Coefficient	Standard Error	Standardized Coefficient	*t*	*p*
Interaction effect (M_2)					
Burden * Distress	0.67	0.83	0.11	0.81	.426
Main effects (M_1)					
Burden	-13.04	21.51	-3.76	-0.61	.549
Distress	-8.24	9.60	-0.08	-0.86	.398

Discussion

Summary

The goal of the present thesis was to assess the roles of symptom distress (representative of menstrual cycle-related symptoms and their intensity) and burden (closely related to perceived tracker comfort) when wearing physical activity trackers in the context of participants' compliance in studies using PATs to self-track. This investigation posed the opportunity to extend the list of factors influencing participants' compliance in studies like this by menstrual cycle-related symptoms, with additional insights into a possible indirect effect of this via the perceived burden.

The results showed a significant positive effect of both retrospective menstrual and premenstrual distress on participants' compliance during these phases. So, within this sample, reporting higher menstrual distress over the last 12 months in the MEDI-Q (Vannuccini et al., 2021) was associated with heightened compliance, in the form of less tracker non-wear time, during the menstrual phase of the study period. The same association between retrospective premenstrual distress and compliance was found during the premenstrual phase of the study period.

Confirmatory Research Question RQ 1

The indirect effect of symptom distress across the entire cycle on non-wear time across the entire study period through overall burden was checked with a mediation analysis. All of the related paths as well as the indirect and total effect were non-significant. Both of the hypotheses were rejected.

In the section *Theoretical Background*, different reasons as to why compliance in menstruating individuals could be affected by their (retrospective) symptom distress are listed: For one, it was argued that based on prior associations between menstrual (Tanaka et al., 2013) and premenstrual (Dennerstein et al., 2010) symptom severity and their impact on menstruating people's daily lives, the same correlation could be assumed for the entire cycle. Therefore, the adapted version of the MEDI-Q could be used as an indirect measure of menstrual cycle-related symptoms and their intensity. The presence and intensity of menstrual cycle-related symptoms, in turn, were assumed to influence compliance both directly and indirectly. Directly, due to possible negative motivational impacts (Schoep et al., 2019), the known adverse impact of pain symptoms on the aspects of work, productivity (Leon-Larios et al., 2024) and forgetfulness (Keogh et al., 2014), as well as due to the close relation of the symptoms of tiredness (Ansari et al., 2025) and impaired concentration (Bajpai

et al., 2025) with forgetfulness. Indirectly, because of symptoms that are likely to worsen the experience of wearing the PATs used, like swelling when wearing ring trackers or lower abdominal pain when wearing belt-worn trackers. The resulting discomfort, a concept closely related to this study‘s measure of *burden*, is a factor frequently reported to impact the compliance in studies that use self-tracking (Brakenridge et al., 2018).

Considering the statistical outcome of the related analysis, for this sample, the research question *Is participants' compliance in menstruating individuals affected by their symptom distress over the last 12 months?* has to be answered in the negative.

Regarding the general population of menstruating individuals, though, the answer is less clear. Aside from the limited sample size and its impacted representativeness, other factors might have also played a role in why the hypothesized effects were not found. Participants might have been interested in the topic and/or personally affected by heightened symptom distress, which would be likely to influence compliance positively, as related meta-findings on longitudinal health research suggest (Bradley et al., 2016; Daniels et al., 2006; Park et al., 2016). This mechanism is discussed further in section *Exploratory Research Question E 3*. This possible positive effect of symptom distress on compliance might have overshadowed any of the proposed negative ones. Therefore, no final conclusion can be drawn regarding the general population of menstruating individuals.

Exploratory Research Question E 2

The indirect effect of menstrual distress (using MEDI-Q score B) on non-wear time within the menstrual phase of the study period through burden during this phase was checked with a mediation analysis. The same analysis was repeated for the premenstrual phase (and MEDI-Q score C) and the intermenstrual phase (and MEDI-Q score D). For all 3 analyses, neither the related paths nor the indirect or total effects were significant.

Similarly as the confirmatory research question, the exploratory research question E 2, *Does the burden of wearing a physical activity tracker explain the relation between menstrual/premenstrual/intermenstrual distress over the last 12 months and participants' compliance?*, cannot be answered with *yes* for any of the three phases investigated, based on the statistical analyses of the current sample. Due to the theoretical background for the relationship between distress, burden and compliance across the whole cycle and within these 3 phases being identical, the same considerations regarding the answer for the general population of menstruating individuals (as mentioned in section *Confirmatory Research Question*) apply here as well.

Exploratory Research Question E 3

In order to check whether the interaction of burden during the menstrual phase and menstrual distress (using MEDI-Q score B) predicted the non-wear time during the respective study period, a moderation analysis was carried out. This was repeated for the premenstrual phase (and MEDI-Q score C) and the intermenstrual phase (and MEDI-Q score D). The main effects of menstrual and premenstrual distress on the non-wear time during the respective study periods were the only significant outcomes.

Considering these results, the exploratory research question E 3, *Does menstrual/premenstrual/intermenstrual distress over the last 12 months affect the strength of the relation between the burden of wearing a physical activity tracker and participants' compliance?*, cannot be answered in the positive for any of the three phases investigated in the current sample. Regarding the general population of menstruating individuals, no final conclusions can be drawn.

In contrast to the results of RQ 1 and E 2, two of the analyses regarding E 3 showed consistent significant results, both with and without the exclusion of outliers: Greater reported values for premenstrual and menstrual distress using the MEDI-Q were associated with less non-wear time during the premenstrual and menstrual period of the study phase. So, as opposed to the reasoning in the section *Theoretical Background*, the presence of higher symptom intensity did not, in fact, relate to more non-wear time, but to less of it.

Notably, it is unlikely that either of the two measures' values of validity are the reason for this association: The daily tracker wear time or lack thereof is a commonly used objective compliance measure in related studies (Chan et al., 2022). Moreover, even though the MEDI-Q might not have been ideal to assess the presence of menstrual cycle-related symptoms and their intensity (due to its output being symptom distress, the impact of symptoms on areas of daily life), there is no reason as to why it should reverse the actual effect of menstrual cycle-related symptoms and their intensity on compliance.

Instead, the relation between the two measures might have been overshadowed by biases regarding the sample. Firstly, the character trait *conscientiousness*, which describes a person's sense of responsibility and dutifulness, has been found to be an influential factor to compliance in similar studies (Martinez et al., 2021), though in some cases only for the majority, not the entirety, of the study period (Faust et al., 2017). The present sample is, in parts, likely to have shown heightened conscientiousness. This is due to the fact that, for those recruited outside of a university context through word of mouth and snowballing, it is likely more conscientious acquaintances were chosen, whether intentionally or not.

Additionally, it is likely there was a selection bias present over time, where less conscientious people either dropped out sooner themselves or they were more likely to show insufficient tracker wear times, leading to exclusion post-data collection. The sample's rather small variation in the compliance measure of non-wear time suggests the same. On the other hand, psychology students, which made up the other part of the sample, have been found to be less conscientious than the average population (Hanel & Vione, 2016), possibly counteracting this tendency. In order to make this statement with actual certainty, though, the participants' personality traits would have had to be objectively measured, which was not the case. Moreover, contrasting findings to the positive influence of conscientiousness on compliance have been found as well. For example, Harari and colleagues (2017) only found this effect for the personality traits *extraversion* and *agreeableness* – for which the opposite effect has been found as well (Faust et al., 2017; Martinez et al., 2021) – while Hermsen and colleagues (2017) did not find an effect of any of the personality traits. Taken together, findings on the possible effect of conscientiousness on compliance are quite heterogenous. Furthermore, no objective measure of personality traits was applied for this sample. The resulting uncertainty makes it impossible to tell whether this sample's conscientiousness complied with the average and, if not, whether and what kind of effect this had on the compliance exactly.

Secondly, people with higher symptom distress might show more motivation to assist with research in any related field, especially given the historical lack thereof mentioned above, as well as the fact that participants were not aware of why exactly they wore the trackers and which relations would be investigated afterwards. This initial motivation might have been fostered during the premenstrual and menstrual phase, with the occurring (pre)menstrual symptoms perhaps serving as some sort of reminder. In result, participants with higher retrospective (pre)menstrual distress, most likely associated with higher (pre)menstrual symptoms during the study, might have felt even more compelled to act compliantly and wear their trackers during this experience, rather than, in a way, allowing themselves to wear the PATs less. The fact that this effect was non-significant for the intermenstrual phase is most likely due to the rather small variation in intermenstrual distress. Although there is no way to verify its application in this case, related research findings suggest a mechanism of this sort: For one, Bradley et al. (2016) reported that, among their sample of 65 members of a patient-centered research platform, the most common motivation for applying for a position in an advisory panel was their needs in relation to their condition. Furthermore, their own condition was the research topic they showed the most interest in. For their sample of 183 mothers who had taken part in a longitudinal health study, Daniels et al.

(2006) found a contribution to science (for 93%) and gaining knowledge about their own pregnancy (for 82%) as the leading motivators for study participation. Park et al. (2016) investigated the role of participants' (n = 4.216) reasons to join the study as a predictor of whether they stayed in it or not. Even though the reasons were no significant predictor when demographic variables were controlled for, they were still considered important to whether the participants stayed in the study. For example, 77.9% of those who answered it was very important to them to help the research team learn more stayed in the study, while, of those who answered this was somewhat or not important to them, only 75.1% did. Taken together, these findings suggest supporting research in the respective field and a concern for one's own medical- or health-related situation are key motivators to engage with and to stay in longitudinal health studies. For the current study, different motivators for participation were not assessed. Some of the statements made by participants (that they were happy to partake in the study because it felt like a meaningful topic to them, for example), though, could imply that the topic was highly relevant to them personally which might have played an important role in how compliant they were.

Strengths and Limitations

One major strength of this study was the effort to recruit participants outside of the university context. With over 40% of the sample partaking outside of the University of Vienna's LABS-system and over 50% reporting no completed vocational training of this sort, this effort can be viewed as successful.

The study team's availability posed another positive aspect of the study. Participants were able to reach out to a member of the study team at any point, either via e-mail or via the direct chat on m-Path, the study app installed on their private smartphones. Participants were also clearly encouraged to do so if they had any question or if something came up. This offer was used quite frequently by participants, potentially preventing a higher number of dropouts.

Another mentionable strength was the implementation of qualitative questions in the form of the end-of-study interview. Since this was a feasibility study for a future project, valuable input and opinions, on the physical activity trackers used or certain questions in the daily online questionnaire, for example, were able to be collected by doing so.

Finally, the present thesis shed light onto the experience and compliance of menstruating individuals in longitudinal studies using PATs, a population that has been historically underrepresented in health and medical research. By investigating menstrual cycle-related symptoms and their intensity as a possible influencing factor of compliance, it

not only contributed to possibly reducing researchers' expense, but also to a possible improvement of the research findings' accuracy and applicability, which, in turn, this population benefits from.

Although the present study possesses these valuable strengths, there are also some points of criticism that can be made. The first one regards the retrospective character of the MEDI-Q, the questionnaire used to collect participants' symptom distress. Applying its adapted version, as described above, they were asked to list the symptoms they experienced and/or the distress caused by those symptoms over the course of the 12 months prior. The practice of using retrospective questions (asking about past symptoms instead of current symptoms) faces criticism within the field of symptom assessment and menstrual cycle-related diagnostics (Eisenlohr-Moul et al., 2017). This is due to the oftentimes weakened validity of these measures in comparison to prospective ones (Schmalenberger et al., 2021), meaning the accuracy of the construct that is meant to be assessed is impacted. Aside from retrospective bias, beliefs about menstruation and menstrual cycle-related symptoms have also been found to distort answers to retrospective measures (Marván & Cortés-Iniestra, 2001), which might have additionally affected the validity of the MEDI-Q scores. To avoid this, the questions regarding symptoms within the daily questionnaire could have been extended to feature all MEDI-Q symptoms, though the effort for participants would have been increased by doing so.

A different issue in relation to the MEDI-Q was brought about by applying its definition of the menstrual, premenstrual and intermenstrual phase to each study period. While, for the majority of participants, all 3 phases could be identified, this was not the case for all of them. Because the MEDI-Q defines the premenstrual phase as the 7 days prior to menstruation, for the participants who started the study period in the menstrual phase and ended without reporting a second one, this could not be identified. Furthermore, for some participants it was not possible to identify 7 premenstrual days, for example, if they started their menstruation on day 5 of the study period already. Additionally, since most participants did not report a second menstruation during their study period, some premenstrual days probably have been assigned to the wrong, the intermenstrual, period. To avoid this, participants who started during their menstrual period could have been asked to continue until reporting the start of their next menstrual period, though this would have meant greater logistic effort.

Regarding the sample, limitations include that it was not fully representative of the average population. In terms of age and gender, for example, it overly represented young

cisgender women. Furthermore, a sample size of only 48 participants could be used in the present thesis, falling below the targeted sample size of 60 participants, which would have been in line with the current guidelines for feasibility studies (Eldridge et al., 2016; Orsmond & Cohn, 2015; Teresi et al., 2022).

Implications

Since this, presumably, was the first time the presence of menstrual cycle-related symptoms and their intensity were investigated as a potential influencing factor of compliance in studies using PATs and self-tracking, future research is still needed to check whether a relation, and in which direction, between the two can be assumed, as well as the presence of indirect effects.

Based on the current study, a few points should be considered when planning future follow-up studies: Firstly, a direct measure of the presence of menstrual cycle-related symptoms and their intensity should be applied, ideally one that is prospective instead of retrospective, to ensure the highest validity attainable. Moreover, if the identification of the premenstrual phase is solely based on the start of the menstrual phase, it should be arranged so that for each participant this could be identified, no matter their study start. Additionally, because the used construct of burden is not fully identical with that of comfort, known to influence compliance, both of these measures should be collected. Their correlation with one another as well as their relation with compliance should be checked. Participants' personality traits ought to be collected as well, to investigate their possible role in regard to compliance. Lastly, to account for a possible positive influence of symptom distress on compliance, the study theme would need to not be centered around the menstrual cycle, if possible. This would be to avoid the partaking of people specifically interested in and/or personally affected by this topic and probably highly motivated to be compliant. Instead, a cover story could be used to assess the influence menstrual cycle-related symptoms and their intensity have on any regular, if one will, study using PATs and self-tracking.

Conclusion

In conclusion, based on the present thesis' results, the presence of menstrual cycle-related symptoms and their intensity do not appear to influence participants‘ compliance in studies using PATs to self-track negatively. Due to the novelty of this investigation, though, it is impossible to draw any final conclusions regarding their relation, as well as the relation between burden and these two. Further research is needed and should ideally address all of the aforementioned considerations in the section *Implications*, that came about while

conducting and evaluating the present study. Eventually, this could provide the field of physical activity research, specifically among menstruating individuals, with valuable insights regarding influential factors of compliance and, perhaps, even with ways on how to deal with them best.

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List of Abbreviations

ADL	Activities of daily life
AI	Artificial intelligence
E 2	Research question 2
E 3	Research question 3
IUD	Intrauterine device
LABS	Laboratory Administration for Behavioral Science
M	Mean
MEDI-Q	Menstrual Distress Questionnaire
MoVo-Konzept	Motivation Volition Concept (Motivations-Volitions-Konzept)
MoVo-LISA	Lifestyle-Integrated Physical Exercise (Lebensstil-Integrierte Sportliche Aktivität)
NIH	US National Institutes of Health
PA	Physical activity
PAT	Physical activity tracker
PCOS	Polycystic Ovarian Syndrome
RQ 1	Research question 1
SD	Standard deviation
VIF	Variance inflation factor
WHO	World Health Organization

Appendix A: Supplementary Figures

Figure A 1

Variation in Daily Non-Wear Time Across the Entire Study Period

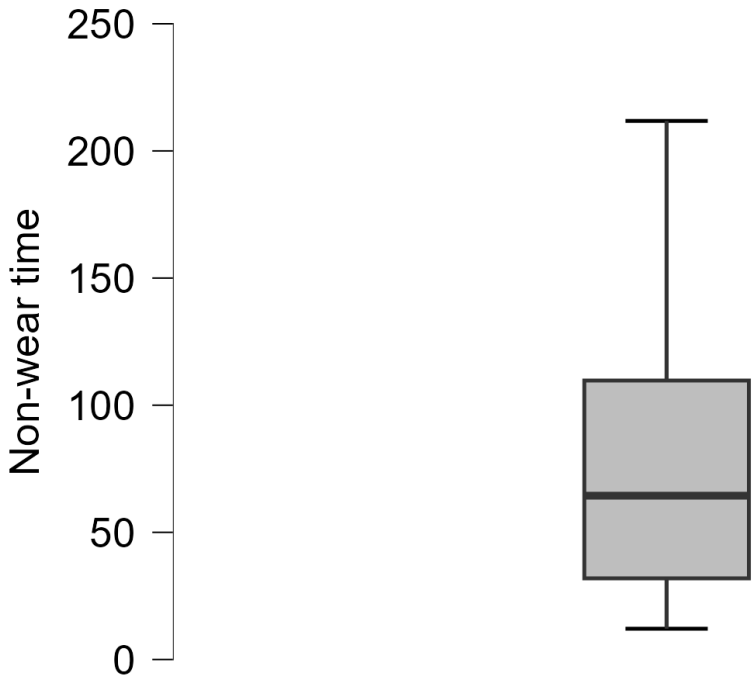
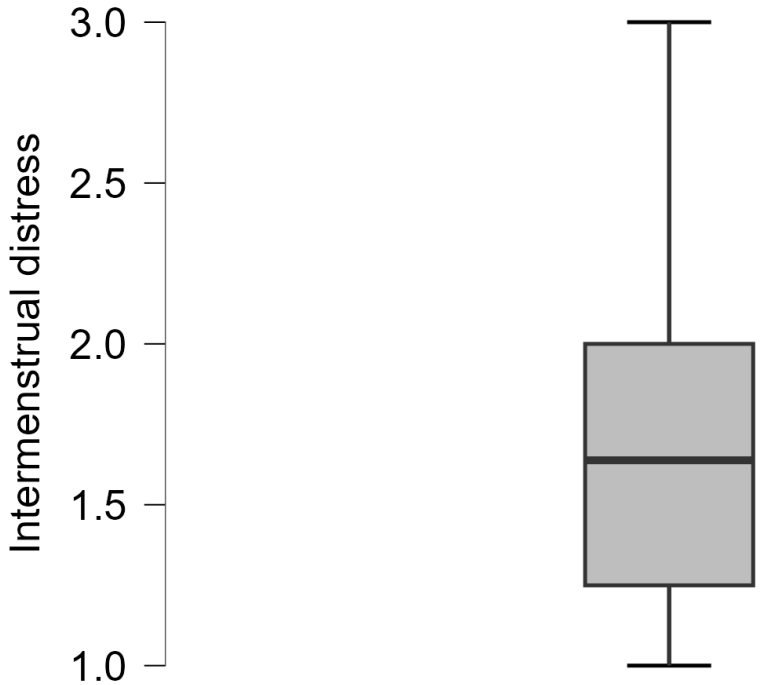


Figure A 2

Variation in Intermenstrual Distress



Appendix B: Declaration on the Use of Artificial Intelligence (AI)

Hiermit erkläre ich, dass ich die folgenden KI-Hilfsmittel zur Erstellung meiner Masterarbeit mit dem Titel *Participants' Compliance with Wearing Physical Activity Trackers: The Role of Menstrual Cycle-Related Symptom Distress* verwendet habe. Ich versichere, dass die Kennzeichnung der verwendeten KI-Hilfsmittel vollständig ist, inkl. Verwendungszweck, Produktname, als auch ggfs. Prompts und Outputs des KI-Hilfsmittels. Ich verantworte die Auswahl und die Übernahme sämtlicher Ergebnisse der von mir verwendeten KI-Hilfsmittel vollumfänglich selbst.

Verwendungszweck	**Produktname des KI-Hilfsmittels**
Anwendung von RStudio	ChatGPT, Google AI
Ausführen der Voraussetzungstests in JASP	ChatGPT
Grammatikalische Korrektheit einiger Satzstrukturen	Google AI

Alternativ:

☐ Ich bestätige, dass ich zur Erstellung meiner Masterarbeit keine KI-Hilfsmittel verwendet habe.