The Effect of Psychoeducation on Perceived Stress and Well-being in Connection to Stress-Measuring Wearables

Daria Mirferdows

Department of Psychology, University of Twente

202000375 Bachelor Thesis Health Psychology and Technology

1st Supervisor: Matthijs Noordzij

2nd Supervisor: Jorge Piano Simoes

July 3, 2024

Abstract

Stress, even though it is an essential bodily state, can be associated with mental as well as physical dysfunctions and diseases when it is chronic. The need to manage stress is prevalent, and stress-measuring wearables offer great potential. However, they do not come without limitations, including potential adverse effects regarding self-management abilities and stress which ultimately can lead to less well-being. Psychoeducational interventions (PIs) already offer a possible alternative to pharmacological interventions targeting stress or well-being, for instance, in clinical contexts. Therefore, this study investigated the potential of PIs to influence perceived stress and well-being in connection with wearables that offer stress monitoring and coaching. In an experimental design, with a control and a psychoeducational group, the effect of PIs on both perceived stress and well-being was examined over 24 hours. The PSS-10 scale for perceived stress and the PANAS scale for positive and negative affect have been used for measurement. All scales have been analysed with the Mann-Whitney U test. In total, the data of $n = 34$ participants have been analysed. The research findings show no significant differences between groups on perceived stress in this sample ($U = 42$, $p = 0.254$). Also, no significant differences were found between both groups on both positive affect ($U = 6$, $p = 0.945$) and negative affect ($U = 19$, $p = 0.729$). This leads to the conclusion that PIs do not show to have any influence on perceived stress and well-being connected to stress wearables. Future studies are recommended with changes in the design, including longer timeframes, pre-post measurement, and ensuring that participants interact with the wearable. Moreover, it is suggested to further investigate the concept of self-management in connection to PIs and wearables.

The Effect of Psychoeducation on Perceived Stress and Well-being in Connection to Stress-Measuring Wearables

Stress is a tense condition induced by situations that pose difficulties (World Health Organization, 2023). Even though stress is an important function of our bodily system and can help us achieve daily tasks, high, chronic stress can lead to detrimental effects on physical and psychological health, resulting in various diseases and dysfunctions. Therefore, managing and dealing with stress is of great importance. Wearable devices (wearables) have started to offer physiological stress monitoring and coaching, through sensors that convert physiological signals into indications of heart rate variability (HRV) and stress levels (González Ramírez et al., 2023; Jerath et al., 2023). Despite the opportunities that wearables pose, users can experience difficulties using and understanding e-health tools, such as wearables (van Olmen, 2022). Without sufficient knowledge of stress physiology, including HRV, and the inherent limitations of attempting to measure HRV with a wrist-worn wearable, as found in a study by van Lier et al. (2019), they might misinterpret the indications of their stress levels and perceive even higher stress and less well-being. Psychoeducational interventions (PIs) are already being used in the management of stress and well-being (Barua et al., 2013; van Daele et al., 2011). For instance, to target stress, individuals are provided with education on stress and coping which they can implement in sessions (van Daele et al., 2011). This makes PIs promising interventions for the improvement of well-being and stress.

Stress

Stress is a natural response allowing the organism to deal with dangerous events. There are various definitions for stress, however, in health psychology, stress can be defined as arising "when a person perceives the demands of an environmental stimuli to be greater than their ability to meet, mitigate, or alter those demands" (Epel et al., 2018, p. 147). It is important to separate stress into two different states, namely stress exposure, in the form of a stressor, and the stress response to the exposure of stressors (Dhabhar, 2014; Harkness & Hayden, 2018). Stress responses can be acute and chronic. Acute stress responses, which last from minutes to hours, arise through stressors connected to certain situations, with the reaction being triggered almost immediately in most cases (Dhabhar, 2014; Morales et al., 2022). Chronic stress responses are not characterised by a clear start or end phase, nor any recovery phase leading to a constant need for adaptation, as it is perceived over hours, weeks or even months (Dhabhar, 2014; Epel et al., 2018). On the one hand, acute stress responses can have enhancing effects on the immune system function and serve as important survival mechanisms (Dhabhar, 2014). On

the other hand, chronic stress responses can be related to detrimental effects on psychological and physiological systems resulting in anxiety, depression, stroke, cardiovascular disease, digestive issues, infectious disease, autoimmune diseases and many more (American Psychological Association, 2022; Cohen et al., 2007). While different stress responses can lead to favourable and adverse effects, there are also different models relating to acute and chronic stress responses.

Different models can explain stress responses and their influence on the body. A linear model includes a stressor, with a clear start and end which leads to a short-term stress response and ends with a recovery phase (Epel et al., 2018). It presents a suitable view for understanding acute stress responses as well as the relationship between repeated physiological reactions and long-term influences on the body and health. However, Epel et al. (2018) notice that “stress is multilevel, emergent, and depends on context” (p. 148). Therefore, the linear model fits into a background that includes contextual factors of individual and environmental nature and reactions to stressors during the lifetime. Also, histories with stressors, current and chronic stressors, and protective factors play an important role. Lastly, it needs to be considered that stress responses, including perception and coping responses, are highly individual (Dhabhar, 2014). Due to the individual nature of stress responses, there is a need for factors that can indicate those differences, such as HRV.

Heart Rate Variability

HRV is the "fluctuation in the time intervals between consecutive heartbeats, also known as R-R intervals" and one promising signal to indicate stress responses (Jerath et al., 2023, p. 2). HRV reflects the way the heart can respond to stimuli of a physiological and environmental nature indicated through the balance between the two constituents of the autonomic nervous system (ANS), namely the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS) (Jerath et al., 2023; Kim et al., 2018). The ANS is an important factor for responding to stressors through the regulation of various functions including heart rate, or blood pressure. While the sympathetic part initiates the so-called “fight-or-flight” and induces the reaction of the body regarding acute stressors, the parasympathetic system is responsible for the relaxation phase of the body. SNS action causes shorter intervals between heartbeats, whereas PNS action causes between-heartbeat intervals to be longer (Thayer et al., 2012). HRV relates to activities of the ANS and has different effects on the body.

High or low HRV is related to stress responses. High HRV, dominated by the PNS, is believed to indicate resilience, a better ability to react flexibly to external changes and to offer stress responses as well as higher well-being (Heiss et al., 2021; Jerath et al., 2023; Thayer et

al., 2012). Contrary, lower HRV, influenced by SNS action, is believed to be connected to difficulties regarding the regulation of emotions as well as various diseases (Heiss et al., 2021; Thayer et al., 2012). However, the study by Heiss et al. (2021) shows that both high and low HRV can be associated with psychopathologies including anxiety, schizophrenia, major depressive disorders, or eating disorders such as anorexia. Rather than one extreme being the better, there seems to be an optimal range of HRV indicating a balance between the sympathetic and parasympathetic system. To detect an optimal range, wearables can be used.

Stress Measurement through Wearables

Wearables are worn devices to measure acute stress responses constantly throughout the day. They include sensors to measure physiological activities such as heart rate, temperature, or biomarkers coming from sweat (Cheng et al., 2021). Moreover, the data can be analysed and linked to the internet and external devices such as smartphones (González Ramírez et al., 2023). Wearables are increasingly used for self-management of health. The smartwatch market offers a variety of brands such as Apple, Samsung, Fitbit, and Garmin (Jerath et al., 2023). Certain wearables can determine HRV indicators through optical sensors measuring the pulse. This happens through photoplethysmography (PPG), by lightening the skin with LEDs, which is a cost-saving and easy method (Ghamari et al., 2018; Jerath et al., 2023). By that, blood vessels absorb the light and so-called photodiodes “detect blood-induced light intensity changes” (Jerath et al., 2023, p. 5). Through PPG, pulse rate variability, an analogy for HRV, gets detected and processed to parameters such as the root mean square of successive differences (RMSSD) of P-P intervals (Georgiou et al., 2018; Shaffer & Ginsberg, 2017). The convenient method of PPG is therefore used to create indices of HRV as RMSSD, which provides indications for the physiological stress response.

Wearables possess several positive features. Firstly, through the output of wearables, people can monitor stress responses and causes early, offering the possibility to self-manage stress responses (Jerath et al., 2023). Secondly, smartwatches can be beneficial as they provide tips on reducing stress responses through activities such as breathing or mindfulness techniques. Through bodily insights such as sleep patterns or periods of exercise, individuals can get a bigger picture of their body and lifestyle. Thirdly, the setting of goals as well as monitoring of the progress can help with stress response management (Jerath et al., 2023). However, the following limitations of wearables need to be considered, which people should be informed about.

There is always the potential for inaccuracy and invalidity of the measurements in contrast to professional medical techniques. For instance, van Lier et al. (2019) found that

during shorter periods, parameters such as RMSSD based on PPG signals have a large amount of data loss, even in rather static laboratory environments. Sudden, and short-term or acute stress responses often cannot be validly detected by PPG. Therefore, RMSSD parameters should rather be determined over a longer time and severe stress responses. Furthermore, HRV does not need to be indicative of stress responses as age, level of fitness, excitement, bodily activities, and health status influence HRV (Jerath et al., 2023). Therefore, it is important that users also consider their broader context. Lastly, for stress response management, subjective stress perception is important. Whereas wearables only deliver objective, physiological insights into levels of the stress response, it does not need to be accurate to what the user is feeling like (Jerath et al., 2023). Individuals might perceive and react differently to stressors than they would be detected by the wearable. Those limitations have the potential to negatively impact individuals resulting in stress responses or less well-being.

Wellbeing Related to Self-Management and Wearables

Well-being has different definitions. One of them is that subjective well-being is composed of three different parts, including satisfaction with life, high positive affect (PA), and low negative affect (NA) (Liang & Zhu, 2015). How people cope with PA and NA has an impact on their well-being and this hedonic approach focuses on fulfilling one's goals and achieving happiness (McDowell, 2010; Puente-Martínez et al., 2018). A study identifying the relationship between self-management abilities, well-being, and depression in older adults gathered the following insights: self-management abilities, such as investing in resources and self-efficacy have been related positively to well-being (Cramm et al., 2012). Another study review, examining the connection of e-health tools with increased self-management relating to health goals and well-being, led to ambiguous findings (van Olmen, 2022). On the one hand, smartwatches are often used to relax which can positively influence satisfaction and wellbeing. Also, the measurement of physiological signals helps gain insights into the body which leads to an enhancement in ownership. Karapanos et al. (2016) additionally reveal that wearables such as activity trackers have the potential to be associated with higher well-being as individuals learn to practice healthier behaviours and gain higher self-esteem. On the other hand, several negative effects on well-being need to be considered. For instance, people can feel overwhelmed by the provided information or how to deal with e-health technologies resulting in feelings of loss of control (van Olmen, 2022). Moreover, it can produce "uncertainty, stress, false reassurance, distrust, and avoidance" (van Olmen, 2022, p. 4). Stress and less feelings of self-management can lastly affect wellbeing. While wearables potentially lead to higher stress responses and less well-being, some interventions can deal with these concerns.

Psychoeducational Interventions

Psychoeducational interventions (PIs) offer growing potential as non-pharmacological interventions. PIs are already being used for many psychological or physical diseases such as degenerative diseases, depression, or anxiety, to improve well-being as well as perceived stress management (Barua et al., 2013; Chouinard et al., 2018; Donker et al., 2009; van Daele et al., 2011). Individuals and their families or caregivers are getting provided with education on topics either actively, through individual or group sessions with guidance through therapists, or passively, through leaflets or websites (Donker et al., 2009; Jones et al., 2018). PIs on perceived stress management include the provision of information regarding stress responses and coping which can then be implemented (van Daele et al., 2011). Additionally, PIs provide benefits compared to psychological or pharmacological interventions due to fewer costs, easier administration, and better accessibility (Donker et al., 2009). PIs seem to have promising effects on perceived stress and well-being. For instance, they effectively reduced perceived stress, symptoms of psychological distress and depression, also in patients with amnestic mild cognitive impairment (Chouinard et al., 2018; Donker et al., 2009; van Daele et al., 2011). Well-being also seems to be positively affected through PIs, following a study by Barua et al. (2013) on cancer patients. However, no studies seem to connect the effectiveness of PIs on perceived stress and well-being with wearables, yet. This knowledge gap is aimed to be filled in the current study.

Current Study

Despite the promising potential of stress wearables regarding self-management of stress responses, there is evidence that missing knowledge and understanding of the output can lead to even higher levels of perceived stress and diminished well-being. Studies concerning PIs show promising findings regarding the reduction of perceived stress and the improvement of well-being. Moreover, research still needs to be conducted on PIs and wearables, connected to perceived stress and well-being. Therefore, this study aims to gain insights into whether psychoeducation on the inherent limitations of wrist-worn physiological measurements, and stress physiology, including HRV, influences perceived stress and well-being when engaging with stress wearables by answering the following research questions: 1) Does psychoeducation on stress physiology, including HRV, and limitations to measure HRV on the wrist with PPG, lead to less perceived stress in comparison to the control group?, 2) Does psychoeducation on stress physiology, including HRV, and limitations to measure HRV on the wrist with PPG, lead to higher positive affect in comparison to the control group?, and 3) Does psychoeducation on

stress physiology, including HRV, and limitations to measure HRV on the wrist with PPG, lead to lower negative affect in comparison to the control group?

Methods

Design

An experimental study was conducted using a between-group design, where all participants wore a wearable device offering stress monitoring for one day. The independent variable was psychoeducation, and its effect on the dependent variables of perceived stress and well-being was tested.

Participants

The study consisted of a total of n = 35 participants who participated in this study voluntarily, whereas one participant was excluded resulting in a sample size of n = 34. The sample consisted of 10 males and 24 females with an age range from 18 to 77 and a mean age of 37.94 (SD = 17.863). Participants were evenly divided over the psychoeducation and control conditions to which participants were allocated based on their demographics such as age, gender, or educational status. The participants have been recruited through a mix of convenience, volunteer, and snowball sampling. The volunteer sampling was conducted on SONA systems of the University of Twente through which participants received credits for taking part in the study. Through convenience sampling, participants outside the University of Twente were recruited who did not receive any compensation for taking part in the study whereas, through snowball sampling, some participants again recommended other participants to participate in this study. The inclusion criteria for the current study demanded the participants to be older than 18 years old and to be able to speak and understand either English or German. Moreover, participants needed to indicate whether they checked their stress levels on the wearable now and then, to which everyone answered with “Yes”. All participants gave online informed consent before their participation, according to the guidelines of the Ethics Committee of the University of Twente (see Appendix A). Data from participants have been excluded from the research if their answer was “No” to any of the parts in the informed consent or the debriefing. One participant was excluded from the study as this person answered “No” to the question of “After being informed of the true nature of this research I still consent to participate in this study” which was part of the debriefing.

Materials

The questionnaires were carried out in Qualtrics, which is a web-based survey tool. Researchers introduced the participants to the study by providing them with an introduction sheet on paper. The control group received a sheet with “Summary” and “Instructions” (see

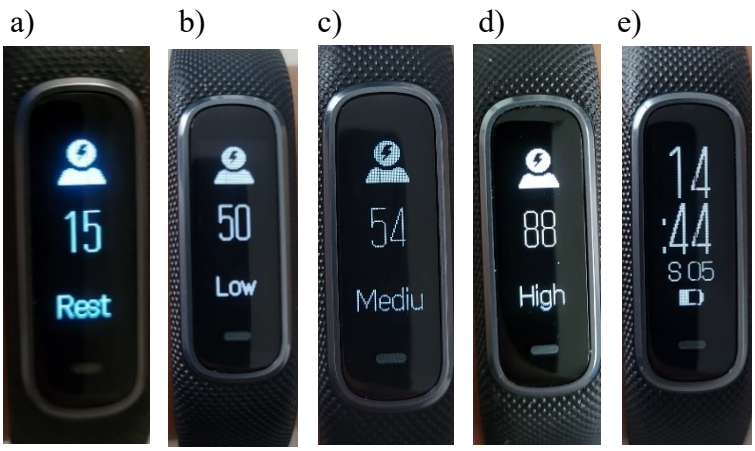
Appendix C), whereas the psychoeducation group sheet included “Summary”, “Instructions” and information on “Stress”, “Stress feedback”, and “HRV” (see Appendix D). The participants were offered the choice to ask questions or to take a picture of the sheet to look at it later that day. Afterwards, the participants received the wearables and a short explanation of how to use them.

Two types of wearables were randomly assigned to the participants, namely the Garmin Vívosmart 4 (see Figure 1) and the Garmin Forerunner 255 (see Figure 2). Both wearables provide indications of stress levels on the display of the wearable and multiple other functions that have not been relevant to the current study. The standard settings for the Garmin Forerunner 255 were applied via the wearable, whereas for the Garmin Vívosmart 4, the Garmin Connect App was used, which works both for iOS and Android. In the app, the language, sequence, and content of the wearable's screen could be adjusted and changed on the wearable via Bluetooth.

The standard setting for the Garmin Vívosmart 4 was the screen with the stress level in numbers and words, which participants could constantly access. They could scroll on the display to view the time, date, and battery level (see Figure 1). The standard setting of the Garmin Forerunner 255 included the time as well as the stress level expressed only in a number on the home screen, which was always available and by pressing the “Down” button, the participants could access their stress level in words and numbers on the display (see Figure 2). Other functions could have been added on the Garmin Forerunner 255 by the participants themselves, whereas on the Vívosmart 4, the participants would have needed to add other functions via the app which was not used in this study.

Figure 1

Visualizations Display of the Garmin Vívosmart 4



Note. a) shows the wearable when the person rests; b) shows the wearable when the person has a low stress level; c) shows the wearable when the person has a medium stress level; d)

shows the wearable when the person has a high stress level; e) shows the time, date, and battery level.

Figure 2

Visualizations Display of the Garmin Forerunner 255

a) b) c)

d) e)

Note. a) shows the wearable when the person rests; b) shows the wearable when the person has a low stress level; c) shows the wearable when the person has a medium stress level; d) shows the wearable when the person has a high stress level; e) shows the home screen with the time, date, battery level, and stress level expressed in a number.

The exit survey consisted of demographic questions (gender, age, nationality, highest level of education), questions on whether participants would already use a wearable in their daily life, and whether they checked their stress level now and then while wearing it (see Appendix B). The other parts of the exit questionnaire were composed of the Perceived Stress Scale (PSS-10) and the Positive and Negative Affect Schedule (PANAS). Lastly, the exit survey included the question of whether participants received the sheet of the control or the psychoeducation group and a debriefing on the study. The informed consent, exit survey, and information sheets were available in English and German (see Appendix A; B; C & D).

Perceived Stress Scale (PSS-10)

The PSS-10 is a self-report measurement and is frequently used to measure the perception of stress. It measures the degree of appraisal of certain situations as stressful on a 10-item scale (Maroufizadeh et al., 2018). The PSS-10 has been translated and used in a variety of different languages, including German (Klein et al., 2016). The PSS-10 is the recommended

version with its psychometric properties being more satisfying than the PSS scales with 14 or 4 items. The items get measured on a 5-point scale in which participants can rate the items from "never" (0), "almost never" (1), "sometimes" (2), "fairly often" (3) to "very often" (4). The items add up to a minimum score of 0 and a maximum score of 40, with higher scores relating to higher perceived stress levels (Maroufizadeh et al., 2018). Whereas the PSS-10 measures experience over the past month, the current study shortened the time frame to one day, during which the wearable was worn (Klein et al., 2016). The PSS-10 showed good validity and internal consistency ($\alpha = 0.89$) for self-reporting perceived stress in a nonclinical sample (Roberti et al., 2006). Moreover, the PSS-10 scale also showed good internal consistency for the German version ($\alpha = 0.84$) (Klein et al., 2016). The sample of the current study also showed good internal consistency ($\alpha = 0.814$).

Positive and Negative Affect Schedule (PANAS)

The PANAS, which is a self-report measure, assesses positive and negative affect on a 20-item scale. There are two subscales including the PA and NA subscales with each scale consisting of 10 items (Liang & Zhu, 2015). Participants needed to rate the experienced emotions such as "interested" or "alert" on a 5-point scale ranging from "very slightly or not at all" (1), to "a little" (2) "moderately" (3), "quite a bit" (4) or "extremely" (5) (McDowell, 2010; Watson et al., 1988). Higher scores stand for higher levels of either PA or NA (Puente-Martínez et al., 2018). There are different timeframes used for the assessment through the PANAS, whereas in the current study, one day was chosen (Crawford & Henry, 2004). The PANAS shown to be effective and reliable in measuring emotional well-being and has appropriate psychometric properties among a sample consisting of a general population of adults (Crawford & Henry, 2004; Liang & Zhu, 2015). Both PANAS subscales showed good reliability with the PA ($\alpha = 0.89$) and the NA ($\alpha = 0.85$) and high construct validity. The current study's sample also showed good internal consistency regarding the overall scale ($\alpha = 0.84$), the PA ($\alpha = 0.889$) and the NA scale ($\alpha = 0.875$).

Procedure

The data collection period was conducted for 5 weeks from the 25th of March until the 30th of April. After the recruiting of participants, the researchers arranged individual appointments to provide them with the wearable. Participants who participated via Sona could sign up for a timeslot there.

The participants were provided a link to Qualtrics to fill out the informed consent (see Appendix A). There, they were informed about the study purpose, duration, and procedures, as well as their right to withdraw and confidentiality of their data. Lastly, they were asked to agree

to the informed consent. During the appointment, the researchers provided the participant either with a fact sheet for the control group (see Appendix C) or a fact sheet for the psychoeducation group (see Appendix D). The participants were offered the chance to ask questions and to take a picture of the sheet to look at it later. Afterwards, the participants were provided with the wearable, including a short introduction on how to use it, and were asked to check their stress levels now and then during the following 24 hours. Then, the participants wore the wearable for approximately 24 hours while checking their stress levels occasionally.

After 24 hours, the researchers collected the wearables from the participants and sent them a second link to the exit survey with the materials described above (i.e. PSS-10, PANAS, intervention checks) (see Appendix B). This survey took approximately 20 minutes to finish and was also conducted on Qualtrics. Finally, the exit survey ended with a debriefing which informed the participants about the true nature of the study, including the experimental two-group design and the study's predictions. All participants were provided with psychoeducation in the end and needed to indicate whether they still wanted to take part in the study after learning about the aforementioned.

Data Analysis

The dataset was downloaded from Qualtrics. Furthermore, R, which is a statistical software environment, was used to analyse the data (R Core Team, 2021). The data were screened and cleaned, and the data of one person were removed because the person did not agree to take part in the study after the debriefing, resulting in a total of 34 participant's data. The data were checked regarding parametric assumptions, including normality, linearity, and homoscedasticity (see Appendix E). Moreover, the data have been checked for outliers by creating boxplots through which one outlier was identified for the PA scale. Descriptive statistics were performed on the demographic data as well as means, standard deviations, and Cronbach's alpha of the PSS-10 and the subscales of the PANAS. Boxplots were created to visualize the distributions of the scales.

Inferential statistics were performed for the PSS-10 and the subscales of the PANAS. Due to potential violations of homoscedasticity regarding both the PSS-10 and the PA subscale of the PANAS, it was decided to test the first and the second research questions with the Mann-Whitney U test. The first research question was tested to see whether the independent variable (IV) of psychoeducation would influence the dependent variable (DV) of perceived stress significantly compared to the control group. The second research question was similarly tested to find out whether the IV of psychoeducation would significantly change the DV of PA. Due to a violation of normality regarding the NA subscale of the PANAS, the third research question

was also examined with the Mann-Whitney U test to see whether the IV of psychoeducation would produce significant differences in the DV of NA compared to the control group.

Results

In total, the data of 34 participants were analysed in this study with each of 17 participants in the psychoeducation and control condition. One participant was excluded from the total of 35 participants. The sample's age range went from 18 to 77. The sample characteristics of both groups can be found in Table 1.

Table 1

Demographic Characteristics of the Participants in the Control and Psychoeducation Groups

	Control				Psychoeducation			
Sample Characteristics	*N*	*%*	*M*	*SD*	*N*	*%*	*M*	*SD*
Gender								
Female	12	70.59			12	70.59		
Male	5	29.41			5	29.41		
Nationality								
Austrian	3	17.65			4	23.53		
German	14	82.35			12	70.59		
Malaysian	0	0			1	5.89		
Highest Education								
Secondary Education	7	41.18			6	35.29		
Vocational Training or Trade School	5	29.41			8	47.06		
Bachelor's Degree	1	5.88			1	5.88		
Master's Degree	2	11.76			2	11.76		
Other	2	11.76			0	0		
Age			41.29	20.97			34.59	13.94

Note. N = Total Number; % = Percentage; M = Mean; SD = Standard Deviation; Control = Control Group; Psychoeducation = Psychoeducation Group.

Furthermore, the descriptive statistics, including the mean and standard deviation of the three scales, namely the PSS-10 and the subscales of the PANAS can be found in Table 2.

Table 2

Descriptive Statistics for the PSS-10 and the PANAS Subscales

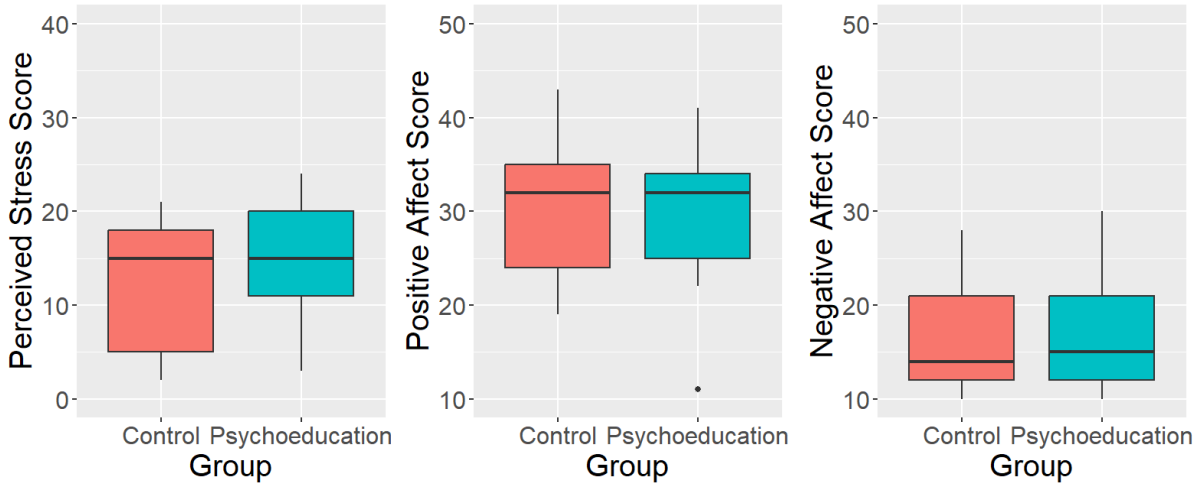
Scale	Both Groups		Psychoeducation		Control	
	M	*SD*	*M*	*SD*	*M*	*SD*
PSS-10	13.5	6.52	14.82	6.25	12.18	6.71
PA	30.03	7.29	29.71	7.26	30.35	7.52
NA	16.47	5.87	16.65	5.87	16.29	6.05

Note. Psychoeducation = Psychoeducation Group; Control = Control Group; M = Mean; SD = Standard Deviation; PSS-10 = Perceived Stress Scale; PA = Positive Affect Subscale; NA = Negative Affect Subscale.

Figure 3 shows the distribution of the data per group for the PSS-10 and the subscales of the PANAS.

Figure 3

Boxplots of the PSS-10 and the PANAS Subscales for Control and Psychoeducation Group



Note. Control = Control Group; Psychoeducation = Psychoeducation Group. The y-axis values run from the scale's minimum to maximum values: PSS-10 = 0:40 & PANAS = 10:50.

Impact on Perceived Stress

The first research question, which examined the impact of group (psychoeducation vs. control) on perceived stress, was tested with the Mann-Whitney U test ($\alpha = 0.05$). There were

no significant differences in perceived stress levels found between the groups through the test (U = 42, p = 0.254), suggesting that psychoeducation did not significantly affect perceived stress levels in this sample.

Impact on PA

The second research question, which investigated the impact of group (psychoeducation vs. control) on PA, was similarly tested with the Mann-Whitney U test (α = 0.05). [1] No significant differences in PA were found between both groups (U = 6, p = 0.945), indicating that in this sample, psychoeducation did not have any significant effect on PA.[2]

Impact on NA

The third research question, checking whether the group (psychoeducation vs. control) had any impact on NA, was also tested with the Mann-Whitney U test (α = 0.05). There were no significant differences in NA found between the groups (U = 19, p = 0.729), suggesting that psychoeducation did not have any significant effect on NA in this sample.

Discussion

The present exploratory study was conducted to test whether psychoeducation on stress wearables, including their chances and risks, would influence perceived stress and well-being. The study's findings show no influence of psychoeducation (including stress physiology and limitations of wrist-worn wearables through PPG) on perceived stress and well-being in this sample. Based on previous literature findings, it was hypothesised that difficulties concerning wearables potentially lead to more perceived stress and lower well-being. For instance, a study by van Olmen (2022) found that e-health technologies, including wearables, can lead to stress and confusion, and in addition to affecting self-management, wearables could ultimately also lead to diminished well-being.

Perceived Stress

The first research question, investigating whether PIs on stress wearables lead to lower perceived stress, could be refuted through the data. The data contradict earlier findings of studies concerning PIs on stress among general population samples, including participants who

---

[1] For the PA scale, a parametric test was also possible, so it was decided to additionally run a linear model. The output, B = -0.64, F (1, 31) = 0.05, p = 0.824, led to the same conclusion, namely, that in this sample, psychoeducation did not have any significant effect on PA.

[2] One outlier was identified for the PA scale. However, since it can be assumed that this outlier is due to the subjective experience of the participant, it was decided that the outlier would not be excluded from the dataset. By running the relevant analyses both with and without outliers, there was no difference in the significance of the results found.

are not highly susceptible to pathologies. For instance, the meta-analytical study by van Daele et al. (2011) reviewed studies on PIs aiming at the reduction of stress. Moreover, a meta-analytical study by Ahmad et al. (2022) reviewed PI studies aimed at the stress management of students in different settings, either online or personal. Both studies have positive findings, ranging from low to high effect sizes. This suggests that PIs can effectively reduce stress among general population samples. Several reasons can be identified for the contradiction of previous literature.

Firstly, the present study is to the current knowledge the first to assess the effectiveness of PIs on perceived stress in connection to wearables. Secondly, despite some findings that show the effectiveness of PIs on stress among a general population sample, they are quite sparse. Instead, PIs are mostly shown to improve stress levels in clinical contexts, in which stress is mostly elevated. For instance, Chouinard et al. (2018) investigated the impact of PIs on stress in patients with amnestic mild cognitive impairment, with positive findings concerning the effectiveness of PIs on stress reduction. Also, a meta-analysis by Donker et al. (2009) shows that passive PIs can effectively reduce symptoms among a sample of participants suffering from depression and psychoeducational distress, however with small effect sizes. Also, some reviewed studies by van Daele et al. (2011), among general population samples, possess criteria indicating for instance the need for participants to score higher than 30 on the PSS-10 scale to be included in the study (Cary & Dua, 1999). This suggests that PIs are mostly successful at the reduction of stress rather than the prevention of it (van Daele et al., 2011). Therefore, the current study's mean scores should be further investigated.

Even though the current study did not assess perceived stress in a pre-post measurement, the mean scores of both, the control and psychoeducation groups, can be compared to other samples of general populations. The current study's means seem similar to those of a representative general German population (Klein et al., 2016). Therefore, it could be suggested, that the current sample did not show any improvements in perceived stress, as a stress reduction was not needed due to non-elevated perceived stress scores. Weiss et al. (2024) provide a similar suggestion in their study in which failure to decrease stress levels through PIs among psychology students was attributed to stress levels that were neither high nor of clinical importance.

However, the data might also lead to a different interpretation. Since it is a pilot study, descriptive statistics have been checked additionally. The mean perceived stress score of the psychoeducation group seems slightly higher than the control group mean. Initially, this would speak against the discussed literature. However, the PSS-10 being a self-report measurement,

is susceptible to certain biases, such as people being likely to report things which they believe to be more socially acceptable (Soria-Reyes et al., 2023). Therefore, another interpretation could also induce that psychoeducation leads to more realistic indications of one's own perceived stress levels, since the PI highlighted that stress should not solely be negatively associated.

Well-being

The second and third research questions, investigating whether PIs on stress wearables would lead to improved well-being, could also be refuted through the data, which contradicts earlier work. For instance, a study by Chiocchi et al. (2019) investigated the effect of PIs on the diminished well-being of caregivers for people with mental health problems. The study findings are shown to be positive in improving mental well-being and feelings of empowerment. Several explanations can be found that might lead to the contradiction of findings.

Again, the current study is the first to investigate the effectiveness of PIs on well-being associated with wearables. Moreover, studies concerning PIs and the well-being of general population samples are sparse. Instead, successful studies are often conducted in clinical contexts. For example, a study by Barua et al. (2013) attempted to see whether PIs would be effective in improving well-being and reducing depression among a sample of patients with breast cancer. Another study by Shinozaki et al. (2019) aimed to increase subjective well-being in schizophrenic patients through PIs. Both studies show positive findings, indicating that PIs can improve well-being in different clinical contexts. Also, Chiocchi et al.'s study (2019), included participants who had lower well-being to start with, without participants having a clinical background. This suggests again that PIs are more effective at improving lower well-being.

Even though the current study did not include a baseline well-being assessment, both groups have higher PA than NA mean scores. Those are similar to the mean scores of a general population sample (Crawford & Henry, 2004). Moreover, other findings indicate that depressed individuals have significantly higher NA and lower PA levels than a sample without depression (Anas & Akhouri, 2013). As the current sample possesses higher PA than NA mean scores, which are comparable to samples among the general population, it can be suggested that elevating well-being through PIs was not successful as it was not low to start with. Besides possible explanations of the contradictory findings, the strengths and limitations of the current study need to be considered.

Strengths and Limitations

First, one of the most valuable strengths of this study is that it is, to the current knowledge, one of the first to investigate the potential effect of PIs on perceived stress and well-being in relation to wearables in an experimental design. Second, the sample for this study was quite heterogeneous concerning age or educational level, which is beneficial for the generalizability of results. Third, the study design, with its control and psychoeducational condition allowed gaining insights into effects that could be attributed to the intervention. Fourth, reliable, and valid measures for perceived stress and well-being were employed with the PSS-10 and the PANAS, which are frequently used measures with high Cronbach's alphas (Crawford & Henry, 2004; Klein et al., 2016; Liang & Zhu, 2015; Roberti et al., 2006).

Apart from the mentioned strengths, some limitations need to be considered. The study had a restricted time frame of 24 hours. Even though this allowed for a greater sample size, participants could have had difficulties accustoming themselves to the wearable fully. Also, this short time frame could have led to difficulties for participants in answering certain questions of the PSS-10 or the PANAS. Another limitation refers to the missing baseline perceived stress and well-being scores of both groups. Whereas the experimental design of groups allowed gaining insights into potential differences between groups, the initial perceived stress and well-being levels of the participants have not been checked while wearing the stress wearable or not wearing it at all. This would have enabled gathering insights into whether psychoeducation would have affected potential low well-being and high perceived stress in individuals.

Future studies

While this exploratory study gains first insights into the potential effectiveness of PIs on perceived stress and well-being connected to wearables, future studies are recommended. Referring to the limitations of the current study, the study design could be tweaked to some extent. To start, it would be encouraged to let people engage with the wearables for more than one day. A study by Nelson et al. (2020) highlighted the integration process of wearables into people's lives. The starting period was identified as the most intense usage period of the wearable as it is getting integrated into daily life. For instance, during the first 2 months, participants indicated that they often engaged with the wearable. Moreover, studies concerning PIs include timeframes of several weeks to months, such as in the study by Weiss et al. (2024). A longer time frame, for instance, 2 months would be beneficial as participants would engage regularly with the wearable and participants could answer the PSS-10 and PANAS over a longer timeframe. By that, this timeframe could be split up into a month each for participants to interact with the wearable before and after a PI.

Also, as mentioned earlier it would be advisable to conduct studies with a pre-post design in which perceived stress levels and well-being are assessed multiple times for each participant. By that, one could investigate individual differences in perceived stress and well-being levels, which is also often the case in PI studies, instead of solely focusing on between-group differences (Barua et al., 2013; Chouinard et al., 2018). Participants could then answer questionnaires both with and without the wearable as well as with and without the PI. Also, as PIs seem more effective on participants with lower well-being and higher perceived stress, it is suggested to separately investigate participants with high NA and low PA scores as well as high PSS-10 scores, such as in the study by Cary and Dua (1999) with PSS-10 scores higher than 30.

However, the PANAS and PSS-10, both self-report measurements, can be susceptible to certain biases (Burger & Caldwell, 2000; Soria-Reyes et al., 2023). Encouraging participants to indicate realistic and bias-free answers could be accomplished by ensuring that participants sufficiently interact with the wearables, since in the current study there was only one question asking if participants looked at their stress levels now and then. This could be done by asking them to note their stress levels throughout the day. Moreover, questionnaires and qualitative measures could be asked to be answered concerning the noted scores to ensure a focus on the wearable.

Lastly, during this research, the central concept of self-management was emphasized. This concerns PIs and their effect on perceived stress and well-being as well as wearables and their implications for self-managing stress. Through wearables, people can monitor and manage their stress responses and well-being through prompts on mindfulness or breathing techniques (Jerath et al., 2023; Karapanos et al., 2016). Also, PIs foster self-management of stress by providing information on coping with stress (van Daele et al., 2011). Therefore, self-management could be introduced in future research as a mediator variable. By this, it could be hypothesized that PIs would lead to higher self-management which would induce less stress and higher well-being.

Conclusion

The current study can be seen as a first step towards connecting PIs with stress wearables and their influence on perceived stress and well-being, which, to the current knowledge, have not yet been connected. For now, no significant relation could be found between PIs and perceived stress in connection with stress wearables in this sample. Moreover, no significant relation could be found between PIs and well-being when interacting with stress wearables. Nevertheless, future studies are recommended with different design choices for instance by

including repeated measures in a pre-post design, ensuring that participants interact with the wearable properly, and longer timeframes. Additionally, further examining the concept of self-management is recommended.

Note on the Use of ChatGPT and Grammarly in this Research Study

OpenAI. (n.d.). *ChatGPT.* [Large language model].
https://chat.openai.com/chat

ChatGPT was used during the phase of data analysis in this research. It was used to support the creation of Codes for R studio and to solve issues that arose during the analysis of those codes. Moreover, ChatGPT was used to support the search processes for fitting analyses and tests for the data.

Grammarly. (2024). *Free Online Grammar Checker.*
https://www.grammarly.com/grammar-check

The grammar checker "Grammarly" was used to check for grammar and other writing mistakes.

References

Ahmad, T. B., Meric, M., & Ayasrah, M. (2022). The Effect of Psychoeducational Stress Management Interventions On Students Stress Reduction: Systematic review. *ECPS, Journal of Educational, Cultural and Psychological Studies/Journal of Educational, Cultural and Psychological Studies*, *25*, 41-57. https://doi.org/10.7358/ecps-2022-025-hass

American Psychological Association. (2022, October 31). *How stress affects your health.* https://www.apa.org/topics/stress/health

Anas, M., & Akhouri, D. (2013). Positive and negative affect in depressed and normal adults. *Journal of Indian Health Psychology. 8*(1), 61-68.

Barua, A., Ram, S., & Narayanasamy, R. (2013). Effectiveness of group psycho-education on well-being and depression among breast cancer survivors of Melaka, Malaysia. *Indian Journal of Palliative Care, 19*(1), 34-9.

Burger, J. M., & Caldwell, D. F. (2000). Personality, Social Activities, Job-Search Behavior and Interview Success: Distinguishing Between PANAS Trait Positive Affect and NEO Extraversion. *Motivation and Emotion*, *24*(1), 51–62. https://doi.org/10.1023/A:1005539609679

Cary, M. & Dua, J. (1999). Cognitive-Behavioral and Systematic Desensitization Procedures in Reducing Stress and Anger in Caregivers for the Disabled. *International Journal of Stress Management, 6*(2), 75-87. https://doi.org/10.1023/A:1022962409572

Cheng, Y., Wang, K., Xu, H., Li, T., Jin, Q., & Cui, D. (2021). Recent developments in sensors for wearable device applications. *Analytical & Bioanalytical Chemistry*, *413*, 6037–6057. https://doi.org/10.1007/s00216-021-03602-2

Chiocchi, J., Lamph, G., Slevin, P., Fisher-Smith, D., & Sampson, M. (2019). Can a carer (peer) led psychoeducation programme improve mental health carers well-being, reduce burden and enrich empowerment: a service evaluation study. *The Journal of Mental Health Training, Education and Practice*, *14*(2), 131–140. https://doi.org/10.1108/JMHTEP-10-2018-0057

Chouinard, A. M., Larouche, E., Audet, M. C., Hudon, C., & Goulet, S. (2018). Mindfulness and psychoeducation to manage stress in amnestic mild cognitive impairment: A pilot study. *Aging & Mental Health, 23*(9), 1246–1254. https://doi.org/10.1080/13607863.2018.1484890

Cohen, S., Janicki-Deverts, D., & Miller, G. E. (2007). Psychological stress and disease. *JAMA*, *298*(14), 1685-1687. https://doi.org/10.1001/jama.298.14.1685

Cramm, J. M., Hartgerink, J., De Vreede, P., Bakker, T., Steyerberg, E. W., Mackenbach, J. P., & Nieboer, A. P. (2012). The relationship between older adults' self-management abilities, well-being and depression. *European Journal of Ageing*, *9*(4), 353–360. https://doi.org/10.1007/s10433-012-0237-5

Crawford, J. R., & Henry, J. D. (2004). The Positive and Negative Affect Schedule (PANAS): Construct validity, measurement properties and normative data in a large non-clinical sample. *British Journal of Clinical Psychology, 43*(3), 245-265. https://doi.org/10.1348/0144665031752934

Dhabhar, F. S. (2014). Effects of stress on immune function: the good, the bad, and the beautiful. *Immunologic Research*, *58*(2–3), 193–210. https://doi.org/10.1007/s12026-014-8517-0

Donker, T., Griffiths, K. M., Cuijpers, P., & Christensen, H. (2009). Psychoeducation for depression, anxiety and psychological distress: a meta-analysis. *BMC Medicine*, *7*(1). https://doi.org/10.1186/1741-7015-7-79

Epel, E. S., Crosswell, A. D., Mayer, S. E., Prather, A. A., Slavich, G. M., Puterman, E., & Mendes, W. B. (2018). More than a feeling: A unified view of stress measurement for population science. *Frontiers in Neuroendocrinology*, *49*, 146–169. https://doi.org/10.1016/j.yfrne.2018.03.001

Georgiou, K., Larentzakis, A. V., Khamis, N. N., Alsuhaibani, G. I., Alaska, Y. A., & Giallafos, E. J. (2018). Can wearable devices accurately measure heart rate variability? A systematic review. *Folia Medica/Folia Medica*, *60*(1), 7-20.

Ghamari, M., Castaneda, D., Esparza, A., Soltanpur, C., & Nazeran, H. (2018). A review on wearable photoplethysmography sensors and their potential future applications in

health care. *International Journal of Biosensors & Bioelectronics*, *4*(4). https://doi.org/10.15406/ijbsbe.2018.04.00125

González Ramírez, M. L., García Vázquez, J. P., Rodríguez, M. D., Padilla-López, L. A., Galindo-Aldana, G., & Cuevas-González, D. (2023). Wearables for Stress Management: A Scoping review. *Healthcare*, *11*(17), 2369. https://doi.org/10.3390/healthcare11172369

Harkness, K. L., & Hayden, E. P. (2018). Introduction. *The Oxford Handbook of Stress and Mental Health.* https://doi.org/10.1093/oxfordhb/9780190681777.013.36

Heiss, S., Vaschillo, B., Vaschillo, E. G., Timko, C. A., & Hormes, J. M. (2021). Heart rate variability as a biobehavioral marker of diverse psychopathologies: A review and argument for an "ideal range". *Neuroscience & Biobehavioral Reviews*, *121*, 144-155. https://doi.org/10.1016/j.neubiorev.2020.12.004

Jerath, R., Syam, M., & Ahmed, S. (2023). The Future of Stress Management: Integration of Smartwatches and HRV Technology. *Sensors*, *23*(17), 7314. https://doi.org/10.3390/s23177314

Jones, R. B., Thapar, A., Stone, Z., Thapar, A., Jones, I., Smith, D., & Simpson, S. (2018). Psychoeducational interventions in adolescent depression: A systematic review. *Patient Education and Counseling, 101*(5), 804–816. https://doi.org/10.1016/j.pec.2017.10.015

Karapanos, E., Gouveia, R., Hassenzahl, M., & Forlizzi, J. (2016). Wellbeing in the Making: Peoples' Experiences with Wearable Activity Trackers. *Psychology of Well-Being*, *6*(1), 1-17. https://doi.org/10.1186/s13612-016-0042-6

Kim, H.-G., Cheon, E.-J., Bai, D.-S., Lee, Y. H., & Koo, B.-H. (2018). Stress and Heart Rate Variability: A Meta-Analysis and Review of the Literature. *Psychiatry Investigation*, *15*(3), 235–245. https://doi.org/10.30773/pi.2017.08.17

Klein, E. M., Brähler, E., Dreier, M., Reinecke, L., Müller, K. W., Schmutzer, G., Wölfling, K., & Beutel, M. E. (2016). The German version of the Perceived Stress Scale – psychometric characteristics in a representative German community sample. *BMC Psychiatry*, *16*(1). https://doi.org/10.1186/s12888-016-0875-9

Liang, Y., & Zhu, D. (2015). Subjective Well-Being of Chinese landless peasants in relatively developed regions: Measurement using PANAS and SWLS. *Social Indicators Research*, *123*(3), 817–835. https://doi.org/10.1007/s11205-014-0762-z

Maroufizadeh, S., Foroudifard, F., Navid, B., Ezabadi, Z., Sobati, B., & Omani-Samani, R.

(2018). The Perceived Stress Scale (PSS-10) in women experiencing infertility: A reliability and validity study. *Middle East Fertility Society Journal*, *23*(4), 456-459. https://doi.org/10.1016/j.mefs.2018.02.003

McDowell, I. (2010). Measures of self-perceived well-being. Journal of Psychosomatic Research, 69(1), 69-79. https://doi.org/10.1016/j.jpsychores.2009.07.002

Morales, A., Barbosa, M., Morás, L., Cazella, S. C., Sgobbi, L. F., Sene, I., & Marques, G. (2022). Occupational Stress Monitoring Using Biomarkers and Smartwatches: A Systematic Review. *Sensors*, *22*(17), 6633. https://doi.org/10.3390/s22176633

Nelson, E. C., Sools, A. M., Vollenbroek-Hutten, M. M. R., Verhagen, T., & Noordzij, M. L. (2020). Embodiment of Wearable Technology: Qualitative longitudinal study. *JMIR Mhealth and Uhealth*, *8*(11), e16973. https://doi.org/10.2196/16973

Puente-Martínez, A., Páez, D., Ubillos-Landa, S., & Da Costa-Dutra, S. (2018). Examining the structure of negative affect regulation and its association with hedonic and psychological wellbeing. *Frontiers in Psychology*, *9*. https://doi.org/10.3389/fpsyg.2018.01592

R Core Team. (2021). R: A language and environment for statistical computing (Version 4.1.1) [Software]. https://www.R-project.org/

Roberti, J. W., Harrington, L. N., & Storch, E. A. (2006). Further Psychometric Support for the 10-Item Version of the Perceived Stress Scale. *Journal of College Counseling*, *9*(2), 135–147. https://doi.org/10.1002/j.2161-1882.2006.tb00100.x

Shaffer, F., & Ginsberg, J. P. (2017). An overview of heart rate variability metrics and norms. *Frontiers in Public Health*, *5*. https://doi.org/10.3389/fpubh.2017.00258

Shinozaki, A., Hayashi, T., & Okamura, H. (2019). Effects of a Psychoeducation Program for People with Schizophrenia Aimed at Increasing Subjective Well-Being and the Factors Influencing Those Effects: a Preliminary Study. *Psychiatric Quarterly*, *91*(1), 45–52. https://doi.org/10.1007/s11126-019-09679-4

Soria-Reyes, L. M., Cerezo, M. V., Alarcón, R., & Blanca, M. J. (2023). Psychometric properties of the perceived stress scale (pss-10) with breast cancer patients. *Stress and Health*, *39*(1), 115-124. https://doi.org/10.1002/smi.3170

Thayer, J. F., Åhs, F., Fredrikson, M., Sollers, J. J., & Wager, T. D. (2012). A meta-analysis of heart rate variability and neuroimaging studies: Implications for heart rate variability as a marker of stress and health. *Neuroscience & Biobehavioral Reviews*, *36*(2), 747–756. https://doi.org/10.1016/j.neubiorev.2011.11.009

The Anti-Fragile Chiro [@drjonathanchung]. (2018, March 27). *Vagal tone and the*

autonomic nervous system is something I've always been curious about since chiropractic school [Diagram of Autonomic Nervous System]. Instagram. https://www.instagram.com/p/Bg1fLbKlziB/?utm_source=ig_web_copy_link

van Daele, T., Hermans, D., van Audenhove, C., & van Den Bergh, O. (2011). Stress reduction through psychoeducation. *Health Education & Behavior*, *39*(4), 474–485. https://doi.org/10.1177/1090198111419202

van Lier, H. G., Pieterse, M. E., Garde, A., Postel, M. G., De Haan, H. A., Vollenbroek-Hutten, M. M. R., Schraagen, J. M., & Noordzij, M. L. (2019). A standardized validity assessment protocol for physiological signals from wearable technology: Methodological underpinnings and an application to the E4 biosensor. *Behavior Research Methods*, *52*(2), 607–629. https://doi.org/10.3758/s13428-019-01263-9

van Olmen, J. (2022). The Promise of Digital Self-Management: A Reflection about the Effects of Patient-Targeted e-Health Tools on Self-Management and Wellbeing. *International Journal of Environmental Research and Public Health*, *19*(3), 1360. https://doi.org/10.3390/ijerph19031360

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology, 54*(6), 1063–1070. https://doi.org/10.1037/0022-3514.54.6.1063

Weiss, E. M., Staggl, S., Holzner, B., Rumpold, G., Dresen, V., & Canazei, M. (2024). Preventive Effect of a 7-Week App-Based Passive Psychoeducational Stress Management Program on Students. *Behavioral Sciences*, *14*(3), 180. https://doi.org/10.3390/bs14030180

World Health Organization. (2023, February 21). *Stress*. https://www.who.int/news-room/questions-and-answers/item/stress

Appendix A

Informed Consent English Version

Consent Form for the Study "Factors Influencing the Use of Stress Wearables Connected to Dimensions of Perceived Stress, Well-being, and Athleticism"

Researchers: Daria Mirferdows, Elisa M. Wüpping

Introduction: You are invited to participate in a bachelor thesis research study investigating wearables in connection with subjective stress perception, well-being and athleticism. Before you decide whether to participate, you must understand the purpose, procedures and potential risks.

Study Purpose: The purpose of this study is to investigate factors influencing the use of stress wearables connected to dimensions of perceived stress, well-being, and athleticism. An exit survey will pose questions about these three dimensions. The examination of these factors allows for a deeper understanding of possible mediators and correlations. Ultimately, these insights will allow for greater insights into the effects of wearables on the user.

Duration:

The duration of participation is approximated at 24 hours with the addition of an exit survey.

Procedures: If you agree to participate, you will be asked to wear the Garmin Forerunner 255 wearable or the Garmin Vívosmart 4 for 24 hours and monitor your stress levels throughout the day. At the end of the 24 hours, you will be expected to fill out an end-of-the-study questionnaire about perceived stress, well-being, and athleticism. The wearable allows for the following measurements none of which will be analysed during the project:

- *Heart Rate Variability Status (HRV)*
- *Step count*
- *Recovery time*
- *GPS-tracking*
- *Heart Rate (HR)*
- *Sleep monitoring*
- *Energy monitoring*
- *Blood oxygen saturation level*
- *Activity tracking*
- *Stress tracking*
- *Respiration*

Your participation in this experiment is completely voluntary and you have the right to withdraw at any given moment without any consequences and without providing any reasons. No harms are expected by participating in this experiment and participants can contact the researchers in case of unexpected adverse effects or questions (contact information is listed below).

Please tick the appropriate boxes

Taking part in the study

I have read and understood the study information dated [18/03/2024], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.

- Yes
- No

I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.

- Yes
- No

I understand that taking part in the study involves wearing the Garmin Forerunner 255 or the Vívosmart 4 wearable all day (except when being in the water) and filling out an exit survey.

- Yes
- No

Use of the information in the study

I understand that information I provide will be used for a bachelor thesis.

- Yes
- No

I understand that personal information collected about me that can identify me, such as [e.g. my name or where I live], will not be shared beyond the study team.

- Yes
- No

Future use and reuse of the information by others

The data will be anonymised and securely stored on servers from the University of Twente. If future publications utilise this study's data, only groups estimates (e.g., mean, median, standard deviations, max, min, etc) will be reported. By clicking this box, I give permission for the questionnaire data that I provide to be archived in the UT data storage so it can be used for

future research and learning. This entails that the thesis will be published on the graduation web of the University of Twente.

- Yes
- No

I understand what taking part in this study will involve. I agree to take part in this study.

- Yes
- No

Please create a personal code consisting of the second letter of your first name + second number of your birthday + first letter of your first pet (if you did not have one use X) + fourth number of your birthday.

(Example code: Max Mustermann, born 04.06.1998, first pet was named Nala. His code would therefore be A4N6)

(Please remember this code or write it down for yourself. You are expected to fill this in again in the exit survey)

Study contact details for further information:

Daria Mirferdows

Elisa M. Wüpping

Study contact details of our supervisor:

Matthijs Noordzij

Contact Information for Questions about Your Rights as a Research Participant

If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee/domain Humanities & Social Sciences of the Faculty of Behavioural, Management and Social Sciences at the University of Twente.

Informed Consent German Version

Einverständniserklärung für die Studie "Einflussfaktoren auf die Nutzung von Stress-Wearables in Verbindung mit Dimensionen von wahrgenommenem Stress, Wohlbefinden und Sportlichkeit"

ForscherInnen: Daria Mirferdows, Elisa M. Wüpping

Einleitung: Sie sind eingeladen an einer Bachelor-Studie teilzunehmen, die Wearables in Verbindung mit subjektivem Stressempfinden, Wohlbefinden, und Sportlichkeit untersucht.

Bevor Sie sich für eine Teilnahme entscheiden, müssen Sie den Zweck, das Verfahren und mögliche Risiken verstehen.

Zweck der Studie: Ziel dieser Studie ist es, die Faktoren zu untersuchen, die die Nutzung von Stress-Wearables im Zusammenhang mit den Dimensionen Stressempfinden, Wohlbefinden und Sportlichkeit beeinflussen. In einer Abschlussbefragung werden Fragen zu diesen drei Dimensionen gestellt. Die Untersuchung dieser Faktoren ermöglicht ein tieferes Verständnis möglicher Mediatoren und Zusammenhänge. Letztlich werden diese Erkenntnisse einen besseren Einblick in die Auswirkungen von Wearables auf den Nutzer ermöglichen.

Dauer:

Die Dauer der Teilnahme beträgt 24 Stunden, hinzu kommt der Fragebogen zum Abschluss des Experiments.

Verfahren:

Wenn Sie sich bereit erklären, an der Studie teilzunehmen, werden Sie gebeten, das Garmin Forerunner 255 Wearable oder das Garmin Vívosmart 4 Wearable 24 Stunden lang zu tragen und Ihr Stressniveau über den Tag hinweg zu überwachen. Am Ende der 24 Stunden werden Sie gebeten, einen Fragebogen auszufüllen, in dem es um das Stressempfinden, das Wohlbefinden und die Sportlichkeit geht. Das Wearable ermöglicht folgende Messungen, von denen keine im Rahmen des Projekts analysiert werden:

- *Herzfrequenzvariabilität (HFV)*
- *Schrittzähler*
- *Erholungszeit*
- *GPS-Ortung*
- *Herzfrequenz (HF)*
- *Schlafüberwachung*
- *Energieüberwachung*
- *Sauerstoffsättigung des Blutes*
- *Aktivitätsverfolgung*
- *Stressniveau*
- *Atmung*

Ihre Teilnahme an diesem Experiment ist vollkommen freiwillig und Sie haben das Recht, jederzeit ohne Folgen und ohne Angabe von Gründen auszusteigen.Es werden keine Schäden durch die Teilnahme an diesem Experiment erwartet. Die Teilnehmer können sich bei unerwarteten Effekten oder Fragen an die Forscher wenden (die Kontaktinformationen sind unten aufgeführt).

Bitte kreuzen Sie die entsprechenden Felder an

Teilnahme an der Studie

Ich habe die Studieninformation vom [18.03.2024] gelesen und verstanden, oder sie wurde mir vorgelesen. Ich hatte die Möglichkeit, Fragen zur Studie zu stellen, und meine Fragen wurden zu meiner Zufriedenheit beantwortet.

-Ja

-Nein

Ich erkläre mich hiermit freiwillig bereit an dieser Studie teilzunehmen und verstehe, dass ich die Beantwortung von Fragen verweigern und die Studie jederzeit ohne Angabe von Gründen abbrechen kann.

-Ja

-Nein

Ich verstehe, dass die Teilnahme an der Studie das ganztägige Tragen des Garmin Forerunner 255 oder des Vívosmart 4 Wearables (außer beim Aufenthalt im Wasser) und das Ausfüllen eines Fragebogens beinhaltet.

-Ja

-Nein

Verwendung der Informationen in der Studie

Ich verstehe, dass die von mir gemachten Angaben für eine Bachelorarbeit verwendet werden.

-Ja

-Nein

Ich verstehe, dass über mich gesammelte persönliche Informationen, die mich identifizieren könnten, [z. B. mein Name oder mein Wohnort], nicht über das Studienteam hinaus weitergegeben werden.

-Ja

-Nein

Künftige Nutzung und Wiederverwendung der Informationen durch andere

Die Daten werden anonymisiert und sicher auf Servern der Universität Twente gespeichert. Wenn zukünftige Veröffentlichungen die Daten dieser Studie verwenden, werden nur Gruppenschätzungen (z.B. Mittelwert, Standardabweichungen, Maximum, Minimum usw.) angegeben. Durch Anklicken des zustimmenden Kästchens erkläre ich mich damit einverstanden, dass die von mir durch den Fragebogen zur Verfügung gestellten Daten im UT-Datenspeicher archiviert werden, damit sie für zukünftige Forschungen und Lernzwecke

verwendet werden können. Dies beinhaltet die Veröffentlichung der Studie im Abschluss-Web der Universität Twente.

-Ja

-Nein

Ich verstehe, was die Teilnahme an dieser Studie bedeutet. Ich bin damit einverstanden an dieser Studie teilzunehmen.

-Ja

-Nein

Bitte denken Sie sich einen persönlichen Code aus der aus dem zweiten Buchstaben Ihres Vornamens + der zweiten Zahl Ihres Geburtstages + dem ersten Buchstabe Ihres ersten Haustieres (wenn sie keines hatten nehmen Sie X) + die vierte Zahl Ihres Geburtstag besteht.

(Beispiel: Max Mustermann, geboren am 04.06.1998, erstes Haustier hieß Nala. Sein Code wäre deshalb A4N6)

(Bitte merken Sie sich diesen Code oder notieren Sie ihn. Sie müssen diesen Code in dem Abschlussfragebogen erneut angeben.)

Kontaktdaten für weitere Informationen:

Daria Mirferdows

Elisa M. Wüpping

Kontaktdaten für Fragen an den Studienbeaufsichtigten:

Matthijs Noordzij

Kontaktinformationen für Fragen zu Ihren Rechten als ForschungsteilnehmerIn

Wenn Sie Fragen zu Ihren Rechten als Studienteilnehmer haben oder Informationen erhalten möchten, Fragen stellen oder Bedenken zu dieser Studie mit einer anderen Person als den Forschern besprechen möchten, wenden Sie sich bitte an das Sekretariat der Ethikkommission/des Fachbereichs Humanities & Social Sciences der Fakultät für Behavioural, Management and Social Sciences der Universität Twente.

Appendix B

Exit Survey English Version

Dear participant,

Welcome to the exit survey of our study on "Factors influencing the use of stress wearables connected to dimensions of perceived stress, well-being, and athleticism". This survey will take you approximately 20 minutes to finish. Note that you have finished the survey when the "thank you" and "your response has been recorded" page appears. After that you can close the website. Please try to answer all the questions as genuine and accurate as possible.

1. Please enter the code that you created when you signed the consent form.

(remember: code consisting of the second letter of your first name + second number of your birthday + first letter of your first pet (if you did not have one use X) + fourth number of your birthday.)

Example code: Max Mustermann, born 04.06.1998, first pet was named Nala. His code would therefore be A4N6

2. If you are a student of the University of Twente and participate via Sona Systems, please fill in your Sona ID here. *(If you are not a student from the Utwente or do not receive credits for taking part in this study please fill in X)*

3. What gender do you identify as?

- Male
- Female
- Non-binary/third gender
- Prefer not to say

4. What is your nationality? *(Please indicate in the field below.)*

5. What is your highest educational level?

- Secondary Education (e.g. high school)
- Vocational training or trade school
- Bachelor’s Degree
- Master’s Degree or higher
- Other

6. How old are you? *(Please indicate your age in numbers)*

7. Do you already use a wearable in your daily life?

- Yes
- No

8. Did you check your stress level on the display every now and then while wearing the wearable?

- Yes
- No

PSS-10

The questions in this scale ask you about your feelings and thoughts during the last day. In each case you will be asked to indicate how often you felt or thought a certain way.

0 = Never; 1 = Almost Never; 2 = Sometimes; 3 = Fairly Often; 4 = Very Often

1. During the last day, how often have you been upset because of something that happened unexpectedly?
2. During the last day, how often have you felt that you were unable to control the important things in your life?
3. During the last day, how often have you felt nervous and "stressed"?
4. During the last day, how often have you felt confident about your ability to handle your personal problems?
5. During the last day, how often have you felt that things were going your way?
6. During the last day, how often have you found that you could not cope with all the things that you had to do?
7. During the last day, how often have you been able to control irritations in your life?
8. During the last day, how often have you felt that you were on top of things?
9. During the last day, how often have you been angered because of things that were outside of your control?
10. During the last day, how often have you felt difficulties were piling up so high that you could not overcome them?

PANAS

Please indicate for the following feelings to what extend you felt this way during the last day (while you were wearing the wearable).

1 = Very slightly or not at all; 2 = A little; 3 = Moderately; 4 = Quite a bit; 5 = Extremely

1. Interested
2. Distressed
3. Excited
4. Upset
5. Strong
6. Guilty

7. Scared
8. Hostile
9. Enthusiastic
10. Proud
11. Irritable
12. Alert
13. Ashamed
14. Inspired
15. Nervous
16. Determined
17. Attentive
18. Jittery
19. Active
20. Afraid

9. When you got introduced to the study, which topics did you have on the fact sheet?

- Summary/ Instructions

- Summary/ Instructions/ Stress/ Stress Feedback/ HRV/ Stress Measurement through Stress Wearables (e.g., diagram with heart)

Debriefing on the Study of "Factors Influencing the Use of Stress Wearables Connected to Dimensions of Perceived Stress, Well-being, and Athleticism"

Dear Participant,

Thank you for your involvement in our research study on *"Factors Influencing the Use of Stress Wearables Connected to Dimensions of Perceived Stress, Well-being, and Athleticism"*.

This form aims to clarify the true nature of our research study. The study's true goal was to find out whether psychoeducation on stress physiology, including heart rate variability and the limitations and chances of stress wearables, influence perceived stress and well-being. Additionally, it includes the question of whether personal levels of athleticism are correlated with different levels of perceived stress. These information have been withheld from you because it might have affected our results.

In this study, you have worn a wearable for 24 hours and finished with an exit survey. In an experimental design, we had two groups, 1) **psychoeducation** and 2) **control group** and you were either part of a group receiving psychoeducation on stress physiology, including heart rate variability and limitations and chances of stress wearables, or receiving solely instructions.

We predict that psychoeducation on the aforementioned topics could lead to less perceived stress, and higher well-being when interacting with wearables. In addition, we predict that a person's level of athleticism is correlated with lower levels of perceived stress. We decided to provide everyone with psychoeducation after their participation in this study, the link can be found below.

However, we ask you **not to share what we are studying with other participants** as this might disrupt the genuine experience other participants have with this research study. If anybody asks you about the study, you can just tell them what we told you during the instructions of this study. No risks have been identified through the withheld information.

Now that you have learned about the true and full purpose of our study and know about the actual study activities, do you still wish to participate in this study? If you say no, your data will not be included in this research project and removed. You can choose to withdraw from this study at any time.

Please tick the appropriate boxes.

I have read and understood the aforementioned information on the true nature of the research study on *"Factors Influencing the Use of Stress Wearables Connected to Dimensions of Perceived Stress, Well-being, and Athleticism"*.

- Yes
- No

After being informed of the true nature of this research I still consent to participate in this study.

- Yes
- No

Lastly, we want to know if you have any questions, suggestions, or comments which you can clarify in the box below *(voluntary)*.

Thank you for participating in our study!

Here is the link for the psychoeducation. *(Please copy the link and open it in a new tab).*

English Version:

https://docs.google.com/document/d/1dUlcfeoSyMliAr2njOJmnLIAmyfGoa4Z/edit?usp=sharing&ouid=104362605683581022018&rtpof=true&sd=true

German Version:

https://docs.google.com/document/d/12rZaGxPwLXx369PD6EkjVhypvEYSStjZ/edit?usp=sharing&ouid=104362605683581022018&rtpof=true&sd=true

If you have any concerns about this study you can contact the researchers:

Elisa M. Wüpping

Daria Mirferdows

You can also contact our supervisor or the Ethics Committee:

Matthijs Noordzij

Secretary of the Ethics Committee/domain Humanities & Social Sciences of the Faculty of Behavioural, Management and Social Sciences at the University of Twente.

Exit Survey German Version

Liebe Teilnehmerin, lieber Teilnehmer,

herzlich willkommen zur Abschlussbefragung unserer Studie zum Thema *"Einflussfaktoren auf die Nutzung von Stress-Wearables in Verbindung mit Dimensionen von wahrgenommenem Stress, Wohlbefinden und Sportlichkeit"*. Die Beantwortung dieser Umfrage wird etwa 20 Minuten in Anspruch nehmen. Beachten Sie, dass Sie die Umfrage abgeschlossen haben, wenn eine Dankesseite mit "Ihre Antwort wurde aufgezeichnet" erscheint. Danach können Sie die Website schließen. Bitte versuchen Sie, alle Fragen so wahrheitsgetreu und genau wie möglich zu beantworten.

1. Bitte geben Sie den Code ein, den Sie bei der Unterzeichnung der Einverständniserklärung erstellt haben.

(zur Erinnerung: der Code besteht aus dem zweiten Buchstaben Ihres Vornamens + der zweiten Zahl Ihres Geburtstages + dem ersten Buchstabe Ihres ersten Haustieres (wenn sie keines hatten nehmen Sie X) + die vierte Zahl Ihres Geburtstag.)

(Beispiel: Max Mustermann, geboren am 04.06.1998, erstes Haustier hieß Nala. Sein Code wäre deshalb A4N6)

Wenn Sie ein Student der University of Twente sind und über Sona Systems teilnehmen, tragen Sie bitte hier Ihre Sona ID ein. (Wenn Sie kein Student der Utwente sind oder keine Credits für die Teilnahme an dieser Studie erhalten, tragen Sie bitte ein X ein)

2. Welchem Geschlecht gehören Sie an?

-Männlich

-Weiblich

-Divers

-Keine Angabe

3. Welche Nationalität haben Sie? (Bitte geben Sie dies in dem nachfolgenden Feld an.)

4. Was ist ihr höchster erreichter Bildungsstand?

-Sekundarschulbildung (z.B. Gymnasium)

-Berufsausbildung oder Berufsschule

-Bachelor

-Master oder höher

-Sonstige

5. Wie alt sind Sie? *(bitte schreiben Sie ihr Alter in ganzen Ziffern)*

6. Benutzen Sie bereits ein Wearable in ihrem Alltag?

-Ja

-Nein

7. Haben Sie während des Tragens des Wearables ab und zu Ihr Stresslevel auf dem Display überprüft?

-Ja

-Nein

PSS-10

Die folgenden Fragen beschäftigen sich mit Ihren Gedanken und Gefühlen während des letzten Tages (während Sie das Wearable getragen haben). Bitte geben Sie für jede Frage an, wie oft sie in entsprechender Art und Weise gedacht oder gefühlt haben.

0 = Nie; 1 = Fast nie; 2= Manchmal; 3 = Ziemlich oft; 4 = Sehr oft

1. Wie oft hatten Sie während des letzten Tages das Gefühl, nicht in der Lage zu sein, die wichtigen Dinge in Ihrem Leben kontrollieren zu können?
2. Wie oft haben sie sich während des letzten Tages nervös und gestresst gefühlt?
3. Wie oft waren Sie während des letzten Tages zuversichtlich, dass Sie fähig sind, ihre persönlichen Probleme zu bewältigen?
4. Wie oft hatten Sie während des letzten Tages das Gefühl, dass sich die Dinge zu Ihren Gunsten entwickeln?
5. Wie oft hatten Sie während des letzten Tages den Eindruck, nicht all Ihren anstehenden Aufgaben gewachsen zu sein?
6. Wie oft waren Sie während des letzten Tages in der Lage, ärgerliche Situationen in Ihrem Leben zu beeinflussen?
7. Wie oft hatten Sie während des letzten Tages das Gefühl, alles im Griff zu haben?
8. Wie oft haben Sie sich während des letzten Tages über Dinge geärgert, über die Sie keine Kontrolle hatten?
9. Wie oft hatten Sie während des letzten Tages das Gefühl, dass sich so viele Schwierigkeiten angehäuft haben, dass Sie diese nicht überwinden konnten?

PANAS

Geben Sie bitte an, wie Sie sich im Verlauf des letzten Tages (während Sie das Wearable getragen haben) gefühlt haben.

1 = Ganz wenig oder gar nicht; 2 = Ein bisschen; 3 = Einigermassen; 4 = Erheblich; 5 = Äußerst

1. Interessiert
2. Bekümmert
3. Freudig erregt
4. Verärgert
5. Stark
6. Schuldig
7. Erschrocken
8. Feindselig
9. Begeistert
10. Stolz
11. Gereizt
12. Wach
13. Beschämt
14. Angeregt
15. Nervös
16. Entschlossen
17. Aufmerksam
18. Durcheinander
19. Aktiv
20. Ängstlich

7. Als Sie in die Studie eingeführt wurden, welche Themen standen da auf dem Informationsblatt?

-Übersicht/ Anweisungen

-Übersicht/ Anweisungen/ Stress/ Stress Feedback/ HFV/ Stressmessung durch Wearables (z.B., Diagramm mit Herz)

Debriefing der Studie "Einflussfaktoren auf die Nutzung von Stress-Wearables in Verbindung mit Dimensionen von wahrgenommenem Stress, Wohlbefinden und Sportlichkeit"

Sehr geehrte Teilnehmerin, sehr geehrter Teilnehmer,

Vielen Dank für Ihre Teilnahme an unserer Studie zum Thema *"Einflussfaktoren auf die Nutzung von Stress-Wearables in Verbindung mit Dimensionen von wahrgenommenem Stress, Wohlbefinden und Sportlichkeit".*

Dieses Formular soll die wahre Natur unserer Forschungsstudie verdeutlichen. Das eigentliche Ziel der Studie war es, herauszufinden, ob Psychoedukation über Stressphysiologie, einschließlich der Herzfrequenzvariabilität und der Grenzen und Chancen von Stress-Wearables, das Stressempfinden und das Wohlbefinden beeinflussen. Darüber hinaus geht es um die Frage, ob das persönliche Maß an Sportlichkeit mit unterschiedlichen Niveaus des Stressempfindens korreliert. Diese Informationen wurden Ihnen vorenthalten, da sie unsere Ergebnisse beeinflussen könnten.

In dieser Studie haben Sie 24 Stunden lang ein Wearable getragen und am Ende eine Umfrage ausgefüllt. In einem experimentellen Design hatten wir zwei Gruppen, 1) **Psychoedukation** und 2) **Kontrollgruppe**, und Sie waren entweder Teil einer Gruppe, die Psychoedukation über Stressphysiologie, einschließlich Herzfrequenzvariabilität und Grenzen und Chancen von Stress Wearables, erhielt, oder Sie erhielten nur eine Einführung und Anweisung.

Wir gehen davon aus, dass Psychoedukation zu den oben genannten Themen zu einem geringeren Stressempfinden und einem höheren Wohlbefinden bei der Interaktion mit Wearables führen könnte. Darüber hinaus gehen wir davon aus, dass der Grad der Sportlichkeit einer Person mit einem geringeren Stressempfinden korreliert. Wir haben uns entschlossen, allen Teilnehmern nach ihrer Teilnahme an dieser Studie die Psychoedukation zur Verfügung zu stellen; den Link finden Sie unten.

Wir bitten Sie jedoch, **anderen Teilnehmern nicht mitzuteilen, was wir untersuchen**, da dies die authentischen Erfahrungen anderer Teilnehmer mit dieser Forschungsstudie stören könnte. Wenn Sie jemand nach der Studie fragt, können Sie ihm einfach sagen, was wir Ihnen bei der Einweisung in diese Studie gesagt haben. Es wurden keine Risiken durch die zurückgehaltenen Informationen festgestellt.

Möchten Sie nun, nachdem Sie den wahren und vollständigen Zweck unserer Studie erfahren haben und über die eigentlichen Studienaktivitäten Bescheid wissen, weiterhin an dieser Studie teilnehmen? Wenn Sie Nein sagen, werden Ihre Daten nicht in dieses Forschungsprojekt aufgenommen und entfernt. Sie können jederzeit von dieser Studie zurücktreten.

Bitte kreuzen Sie die entsprechenden Felder an.

Ich habe die oben genannten Informationen über den wahren Charakter der Forschungsstudie zum Thema *"Einflussfaktoren auf die Nutzung von Stress-Wearables in Verbindung mit*

Dimensionen von wahrgenommenem Stress, Wohlbefinden und Sportlichkeit" gelesen und verstanden.

-Ja

-Nein

Nachdem ich über den wahren Charakter dieser Forschung informiert wurde, stimme ich dennoch zu, an dieser Studie teilzunehmen.

-Ja

-Nein

Zu guter Letzt möchten wir wissen, ob Sie Fragen, Anregungen oder Kommentare haben, die Sie in dem unten stehenden Feld erläutern können *(freiwillig)*.

Vielen Dank, dass Sie an unserer Studie teilgenommen haben!

Hier ist der Link für die Psychoedukation. *(Bitte kopieren Sie den Link und öffnen Sie ihn in einem neuen Tab)*.

Englische Version:

https://docs.google.com/document/d/1dUlcfeoSyMliAr2njOJmnLIAmyfGoa4Z/edit?usp=sharing&ouid=104362605683581022018&rtpof=true&sd=true

Deutsche Version:

https://docs.google.com/document/d/12rZaGxPwLXx369PD6EkjVhypvEYSStjZ/edit?usp=sharing&ouid=104362605683581022018&rtpof=true&sd=true

Wenn Sie Fragen zu dieser Studie haben, können Sie sich an die Forscher wenden:

Elisa M. Wüpping

Daria Mirferdows

Sie können sich auch an unseren Betreuer oder die Ethikkommission wenden:

Matthijs Noordzij

Secretary of the Ethics Committee/domain Humanities & Social Sciences of the Faculty of Behavioural, Management at the University of Twente.

Appendix C

Figure C1

Information Sheet Control Group English Version

Study on Stress Wearables

Summary	We are using wrist-worn wearables to get insights into factors that influence the use of wearables measuring stress and connected to this, dimensions of perceived stress, well-being, and athleticism. 
Instructions	We would like you to wear the wearable for a full 24hrs. The wearable is worn about two fingers from the crease of your wrist to get optimal results. You should feel a slight pressure when the wearable is worn. Please check your stress level multiple times throughout the day. At the end of the 24hrs, you will also fill in a short exit survey.

Note.

Figure C2

Information Sheet Control Group German Version

Studie über Stress Wearables

Übersicht	Wir verwenden am Handgelenk getragene Wearables, um Einblicke in Faktoren zu erhalten, die die Nutzung von Wearables und damit verbunden Dimensionen von wahrgenommenem Stress, Wohlbefinden und Sportlichkeit beeinflussen. 
Anweisungen	Bitte tragen Sie das Wearable volle 24 Stunden lang. Das Wearable wird etwa zwei Fingerbreit von der Handgelenksfalte entfernt getragen, um optimale Ergebnisse zu erzielen. Sie sollten einen leichten Druck spüren, wenn Sie das Wearable tragen. Bitte überprüfen Sie Ihr Stress Level mehrmals am Tag. Nachdem Sie das Wearable für 24h getragen haben werden Sie außerdem eine kurze Umfrage ausfüllen.

Note.

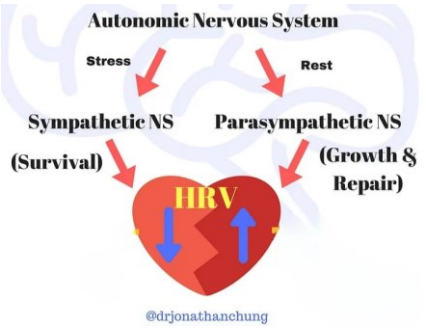
Appendix D

Figure D1

Information Sheet Psychoeducation Group English Version

Study on Stress Wearables

Summary	We are using wrist-worn wearables to get insights into factors that influence the use of wearables measuring stress and connected to this, dimensions of perceived stress, well-being, and athleticism. 
Instructions	We would like you to wear the wearable for a full 24hrs. The wearable is worn about two fingers from the crease of your wrist to get optimal results. You should feel a slight pressure when the wearable is worn. Please check your stress level multiple times throughout the day. At the end of the 24hrs, you will also fill in a short exit survey.
Stress	Although stress often has a negative connotation, in reality, stress can also have benefits: Good Stress: Manageable levels of stress can promote recovery and performance. Bad Stress: Prolonged, chronic stress can cause mental health issues and other adverse effects such as an earlier onset of age-related diseases. There are many forms of stress which are measured differently. We examine stress based on wearables measurements, and therefore focus on physiological stress. This stress is the body's reaction to stressors and is, for example, manifested in heightened heart rate and blood pressure.
Stress feedback	The wearable indicates stress via four different levels: -Resting State: 0-25 -Low Stress: 26-50 -Medium Stress: 51-75 -High Stress: 76-100 ! Be aware that those stress levels can indicate either good or bad stress and the wearable cannot measure that. If the wearable indicates for instance high stress it would be a good time to check with yourself how you feel about this and if you are ready for more challenges or a small break.

HRV	Heart Rate Variability (HRV) relates to the variation in intervals between heartbeats and is a relevant indicator of activities regarding our autonomic nervous system (ANS). The ANS has the function of keeping a balance in our body through the activity of two branches, namely the Sympathetic Nervous System (SNS), which leads to the activation of the body and the Parasympathetic Nervous System (PNS), which is responsible for relaxation.  Lower HRV: domination through the SNS when stress is perceived and low variability between heartbeats Higher HRV: domination through the PNS when body is relaxed and high variability between heartbeats Contrary to the believe that high HRV is good and low HRV bad for the body, new evidence shows that a balance is the optimum.
Stress Measurement through wearables	Wearables measure physiological signals through an optical sensor. This process is called Photoplethysmography (PPG), which works with a light sensor. The light of this sensor gets absorbed by blood vessels and photodiodes detect the changes in the blood volume, indicating the pulse. Algorithms can transform these insights into HRV data based on the intervals of the measured pulse. However, PPG measurements of HRV are often inaccurate. Keep in mind that stress measurement through wearables is not perfect BUT it can also be a helpful tool to self-check and manage your stress.

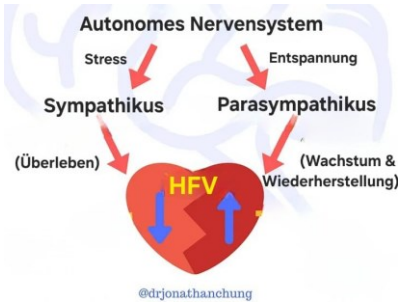
Note. The picture of the autonomic nervous system was shortened. Adapted from *Vagal tone and the autonomic nervous system is something I've always been curious about since chiropractic school*, by The Anti-Fragile Chiro [@drjonathanchung], 2018, Instagram. (https://www.instagram.com/p/Bg1fLbKlziB/?utm_source=ig_web_copy_link)

Figure D2

Information Sheet Psychoeducation Group German Version

Studie über Stress Wearables

Übersicht	Wir verwenden am Handgelenk getragene Wearables, um Einblicke in Faktoren zu erhalten, die die Nutzung von Wearables und damit verbunden Dimensionen von wahrgenommenem Stress, Wohlbefinden und Sportlichkeit beeinflussen. 
Anweisungen	Bitte tragen Sie das Wearable volle 24 Stunden lang. Das Wearable wird etwa zwei Fingerbreit von der Handgelenksfalte entfernt getragen, um optimale Ergebnisse zu erzielen. Sie sollten einen leichten Druck spüren, wenn Sie das Wearable tragen. Bitte überprüfen Sie Ihr Stress Level mehrmals am Tag. Nachdem Sie das Wearable für 24h getragen haben werden Sie außerdem eine kurze Umfrage ausfüllen.
Stress	Obwohl Stress oft negativ konnotiert ist, kann er auch positive Auswirkungen haben: Guter Stress: Ein überschaubares Maß an Stress kann Erholung und Leistung fördern. Schlechter Stress: Anhaltender, chronischer Stress kann zu psychischen Problemen und anderen negativen Auswirkungen führen, z. B. zu einem früheren Auftreten von altersbedingten Krankheiten. Es gibt viele Formen von Stress, die unterschiedlich gemessen werden. Da wir Stress auf der Grundlage von Wearables-Messungen untersuchen, konzentrieren wir uns auf physiologischen Stress. Dieser Stress ist die Reaktion des Körpers auf Stressoren und äußert sich zum Beispiel in einer erhöhten Herzfrequenz und einem erhöhten Blutdruck.
Stress-Feedback	Das Wearable zeigt Stress über vier verschiedene Stufen an: -Ruhezustand: 0-25 -Geringer Stress: 26-50 -Mittlerer Stress: 51-75 -Hoher Stress: 76-100 ! Seien Sie sich bewusst, dass diese Stresswerte guten oder schlechten Stress anzeigen können und das Wearable dies nicht messen kann. Wenn das Wearable z. B. hohen Stress anzeigt, wäre es ein guter Zeitpunkt, in sich zu fühlen und herauszufinden, wie Sie sich dabei fühlen und ob Sie bereit sind für weitere Herausforderungen oder eine kleine Pause.

HFV	 Die Herzfrequenzvariabilität (HFV) bezieht sich auf die Variation der Intervalle zwischen den Herzschlägen und ist ein wichtiger Indikator für die Aktivitäten unseres autonomen Nervensystems (ANS). Das ANS hat die Aufgabe, das Gleichgewicht in unserem Körper durch die Aktivität zweier Zweige aufrechtzuerhalten, nämlich des Sympathikus, der zur Aktivierung des Körpers führt, und des Parasympathikus, der für die Entspannung zuständig ist. Niedrigere HFV: Beherrschung durch den Sympathikus, wenn Stress empfunden wird; geringe Variabilität zwischen den Herzschlägen Höhere HFV: Beherrschung durch den Parasympathikus, wenn der Körper entspannt ist; hohe Variabilität zwischen den Herzschlägen Entgegen der Annahme, dass eine hohe HFV gut und eine niedrige HFV schlecht für den Körper ist, zeigen neue Erkenntnisse, dass ein Gleichgewicht das Optimum darstellt.
Stressmessung durch Wearables	Wearables messen physiologische Signale über einen optischen Sensor. Dieser Prozess wird Photoplethysmographie (PPG) genannt, die mit einem Lichtsensor arbeitet. Das Licht dieses Sensors wird von den Blutgefäßen absorbiert, und Fotodioden erkennen die Veränderungen des Blutvolumens, die den Puls anzeigen. Algorithmen können diese Erkenntnisse in HFV-Daten umwandeln, die auf den Intervallen des gemessenen Pulses basieren. PPG-Messungen der HVF sind jedoch oft ungenau. Bedenken Sie, dass die Stressmessung durch Wearables nicht perfekt ist, ABER sie kann ein hilfreiches Instrument zur Selbstkontrolle und zum Stressmanagement sein.

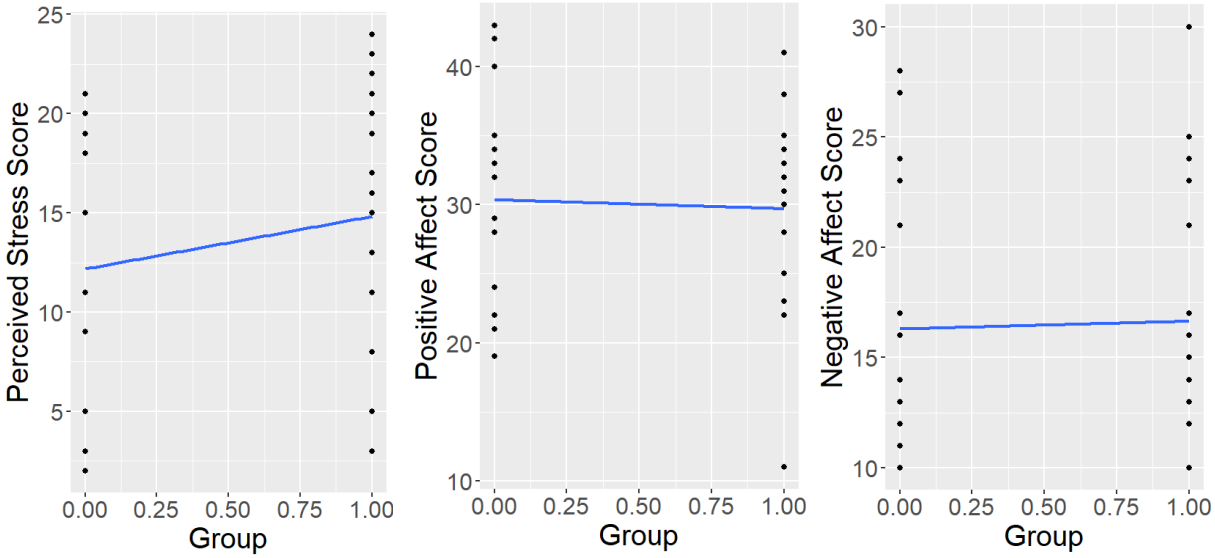
Note. The picture of the autonomic nervous system was shortened and translated to German. Adapted from *Vagal tone and the autonomic nervous system is something I've always been curious about since chiropractic school*, by The Anti-Fragile Chiro [@drjonathanchung], 2018, Instagram. (https://www.instagram.com/p/Bg1fLbKlziB/?utm_source=ig_web_copy_link)

Appendix E

Assumptions Linear Model

Figure E1

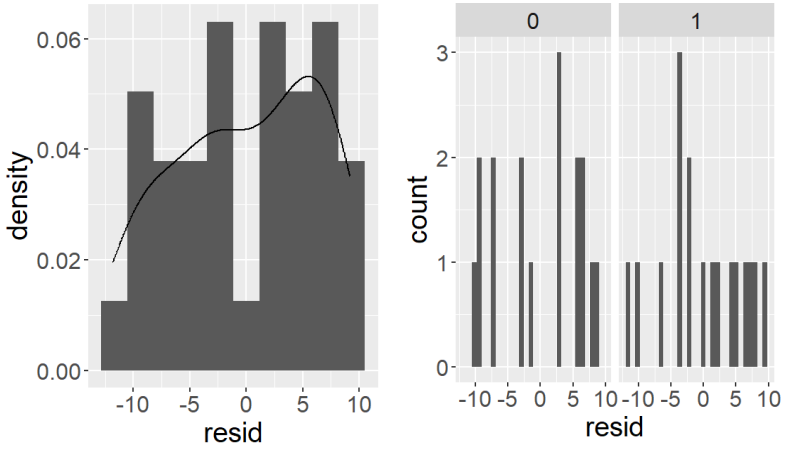
Assumption of Linearity of the PSS-10 and PANAS scales



Note. 0.00 = Control Group; 1.00 = Psychoeducation Group.

Figure E2

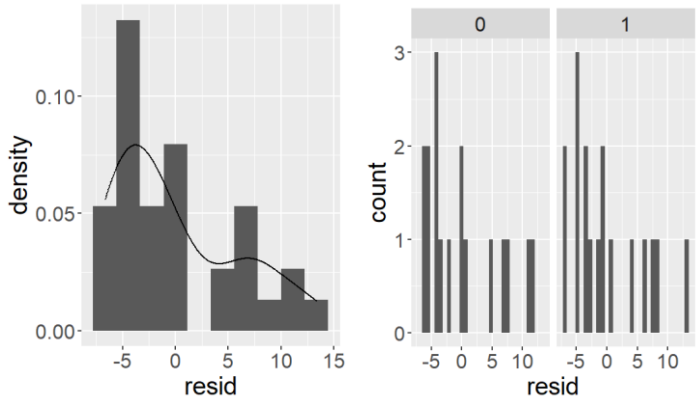
Assumption of Normality for the PSS-10



Note. 0 = Control Group; 1 = Psychoeducation Group.

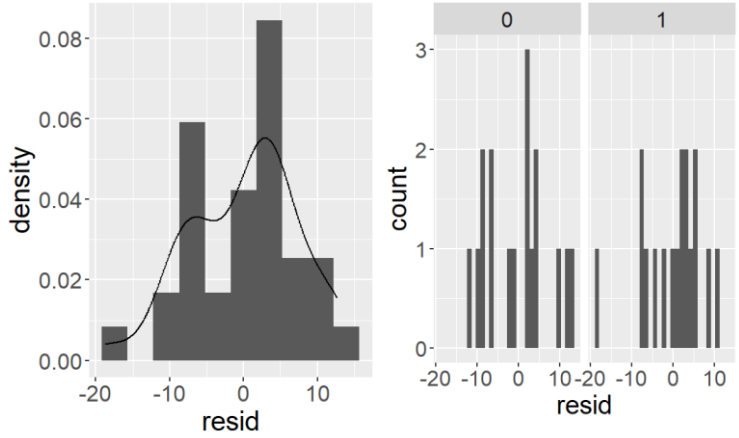
Figure E3

Assumption of Normality for the NA subscale



Note. 0 = Control Group; 1 = Psychoeducation Group.

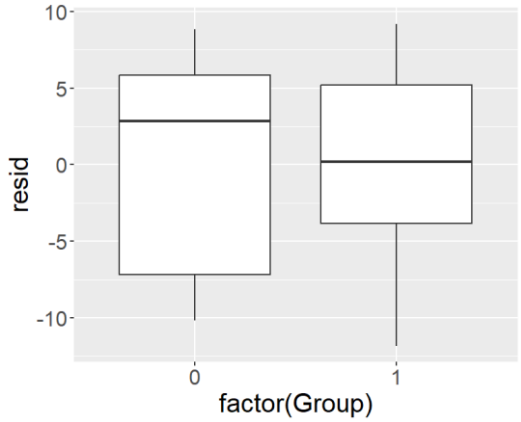
Figure E4 *Assumption of Normality for the PA subscale*



Note. 0 = Control Group; 1 = Psychoeducation Group.

Figure E5

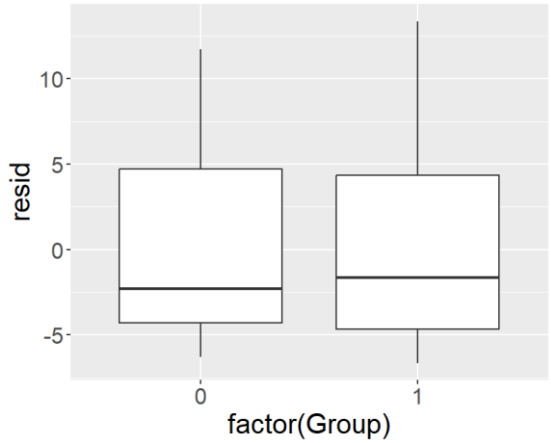
Assumption of Homoscedasticity for the PSS-10



Note. 0 = Control Group; 1 = Psychoeducation Group.

Figure E6

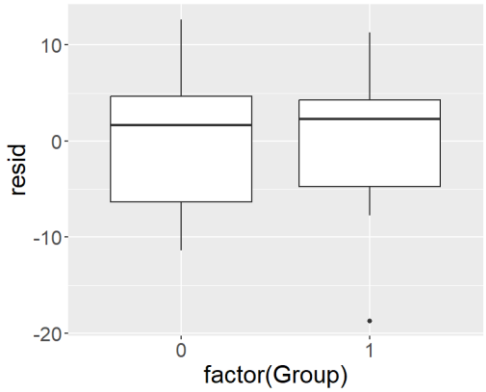
Assumption of Homoscedasticity for the NA subscale



Note. 0 = Control Group; 1 = Psychoeducation Group.

Figure E7

Assumption of Homoscedasticity for the PA subscale



Note. 0 = Control Group; 1 = Psychoeducation Group.