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ORIGINAL RESEARCH

The Influence of Fitness-App Usage on Psychological Well-Being and Body Awareness—A Daily Diary Randomized Trial

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Self-tracking via fitness apps is popular and has been described as a means to enhance body awareness and well-being. However, the effects of fitness-app use and specific app functions on well-being and body awareness have yet to be targeted in controlled experimental studies. In two randomized groups, a fitness tracker was used for 6 weeks, and in one group a daily step target was implemented. In a third control group, participants documented their physical activity. A daily diary method was used to measure well-being and body trusting. In Bayesian multilevel analyses, no time, group, or interaction effects were found. These results were robust when controlling for diverse variables. It can be concluded that exercise-related self-tracking and specific step goals do not substantially influence psychological well-being and body trusting. Considering the large variability in effects, potential effects can be assumed under conditions that are to be identified in further studies.

Keywords*:* digitalization, physical activity, self-tracking

The use of digital media has become an important aspect of people's everyday lives, for example, in work, lifestyle, and health care contexts (Gray & Rumpe, 2015; Latos, Harlacher, Przybysz, & Mütze-Niewöhner, 2017; West et al., 2012). In the field of health and exercise, smartphone fitness applications (apps) that are designed to track and enhance health behavior are currently very popular. In an international representative survey, 33% of the participants said that they track their physical activity via smartphone applications (GfK, 2017). Fitness apps can be combined with matching wearables (e.g., wristbands) and often provide options that deliver information about one's step count, number of calories burned, heart rate, and so forth (Poushter, 2016; West et al., 2012). To encourage their customers to use their apps often, many fitness app providers have also implemented an option for a daily step target (e.g., 10,000 steps per day) into the app settings that can be continuously compared with the current actual step count. Thus, fitness apps provide objective feedback and detailed information about body-related states and processes. Fitness apps are of interest to practitioners for healthcare purposes. In this context, most studies investigating the health-related effects of fitness app usage have indicated that fitness app usage can contribute to health enhancements, such as higher activity levels (e.g., step count), healthier nutrition, or the development of health-related habits (Donnachie, Wyke, Mutrie, & Hunt, 2017; Glynn et al., 2014; Maher et al., 2015; Schoeppe et al., 2016). However, research has also indicated that the use of fitness apps does not significantly affect the number of steps per day or time spent in moderate-to-vigorous physical activity (Romeo et al., 2019). In this context, researchers have mostly focused on outcomes that are related to physical health (Schoeppe et al., 2016). Besides, the effects of fitness app usage (i.e., tracking of body-related data) on mental states and mental health (i.e., psychological well-being, evaluation of and attention to body states) have scarcely been focused on as main research questions in empirical studies.

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Fitness Apps

Well-Being and Fitness Apps

The World Health Organization (WHO) has emphasized mental and social well-being next to physical health as important factors for general health in their core principles (World Health Organization, 1995). Moreover, mental health and psychological well-being have been identified as key priorities in the WHO's sustainable development goals, assumed to have a positive impact on health in communities around the world (World Health Organization, 2005).

In previous research, general well-being has been connected with fitness app usage. It has been indicated that fitness app usage can have beneficial effects on health-related aspects partly connected with mental health, such as healthy eating, body awareness, and sedentary behavior (e.g., Schoeppe et al., 2016; Sharon & Zandbergen, 2017). However, it has also been discussed that fitness apps can increase the visibility of health and can lead to an idealization of the shaped body that is unattainable for most users (Depper & Howe, 2017). In this context, self-tracking via fitness apps could be perceived as a burden and create anxiety in users (Lupton, 2013). Furthermore, it has been indicated that fitness app usage can lead to the manifestation and aggravation of symptoms of disordered eating (Levinson, Fewell, & Brosof, 2017; Simpson & Mazzeo, 2017).

Beyond the background of the mixed findings presented above, it is of high interest to learn about the effects of fitness app usage on psychological well-being. However, to date, we are aware of no studies that have targeted psychological well-being as a main outcome; two studies have investigated psychological well-being as secondary outcomes. In both studies (Glynn et al., 2014; Maher et al., 2015), neither improvement nor deterioration in psychological well-being were found during a fitness app intervention. Consequently, it is of interest to further investigate the effects of fitness app usage on psychological well-being as a main research question. Aside from the effects on psychological well-being, the psychological-related effects of self-tracking have been discussed in the context of practicing body awareness (e.g., En & Pöll, 2016; Sharon & Zandbergen, 2017).

Body Awareness and Fitness Apps

The practice of self-tracking via technical devices such as fitness apps means that a person is constantly focusing on bodily states, and it has been described as a way of practicing body awareness (Nafus & Sherman, 2014; Sharon & Zandbergen, 2017; Wolf, 2010). Body awareness is a multifaceted concept that is used across different fields, including psychology, medicine, and sport and exercise sciences (e.g., Crescentini & Capurso, 2015; Gyllensten, Skär, Miller, & Gard, 2010; Tihanyi, Bőőr, Emanuelsen, & Köteles, 2016). Among scholars, high levels of body awareness are considered to be beneficial. Body awareness has been associated with higher ability to register body sensations (Hebert, 2016) and with psychological well-being (Brani, Hefferon, Lomas, Ivtzan, & Painter, 2014; Köteles, Kollsete, & Kollsete, 2016). In addition, high levels of body listening and trusting have been associated with higher regulatory body-related abilities and are assumed to facilitate the management of diseases such as chronic back pain (Mehling et al., 2009). However, research has also suggested that fitness app usage may be linked to negative body-related concerns such as objectification and anesthetization of human experience (Toner, 2018).

In the field of sport and exercise science, higher levels of body awareness have been found in athletes compared with nonathletes (Minev, Petkova, Petrova, & Strebkova, 2017) and in advanced yoga and Pilates practitioners compared with beginners (Tihanyi, Sági, Csala, Tolnai, & Köteles, 2016). Tracking one's own physiological parameters has been connected with a higher correspondence of perceived stress and objective measures of heart rate (Van Dijk, Westerink, Beute, & Ijsselsteijn, 2015). Thus, in sum, it has been discussed that self-tracking can contribute to the enhancement of body awareness. However, to date, empirical research targeting the effects of fitness app usage on aspects of body awareness is lacking. Consequently, aside from anecdotal experiences and works, it is important to investigate the effects of self-tracking via fitness apps in empirical studies in the context of health-related outcomes.

Self-Tracking and Step Targets

One central function of numerous fitness apps and wearables is a step count that is often combined with an option for a step target (e.g., West et al., 2012). Following recommended levels of physical activity (Tudor-Locke, Brashear, Johnson, & Katzmarzyk, 2010), many wearable providers have implemented a specific predefined target of 10,000 steps per day in their app settings. These specific step targets have been examined in studies focusing on motivational outcomes, such as intrinsic and extrinsic motivation. It has been found that external step targets can undermine intrinsic motivation (Goodyear, Kerner, & Quennerstedt, 2017) and can also convey a feeling of pressure (Lupton, 2014). However, the effects of specific app functions on psychological well-being have yet to be examined. Furthermore, it is unclear if and how the implementation of external step targets can influence the way people listen to and trust their bodily states during fitness app usage.

The Present Research

Continuous self-tracking and the implementation of preset step targets are major elements in fitness app usage. However, potential effects of fitness app usage and specific app functions (i.e., a step target of 10,000 steps per day) on psychological well-being and aspects of body awareness have scarcely been examined in previous research.

Based on current recommendations in fitness app research (Schoeppe et al., 2016), it is crucial to test specific apps and their functions under controlled conditions. Therefore, we aimed to examine two groups using a fitness app device under randomized controlled conditions in a longitudinal multimethod design. In addition to daily assessment of the main variables, we aimed to conduct comprehensive prequestionnaires and postquestionnaires in order to gain a comprehensive understanding of interindividual and intraindividual trajectories, including the variance of outcomes.

To provide a better understanding of the effects of general self-monitoring versus fitness-app-mediated processes, we aimed at (a) implementing two groups using fitness apps, (b) systematically varying the conditions through the implementation of a specific step target in one group (i.e., 10,000 steps per day), and (c) implementing an additional control group that was blinded to the experimental conditions and that monitored their physical activity via self-report, but not via fitness apps.

Beyond the background of the mixed evidence of previous studies, the effects of fitness app usage and the implementation of external step targets on psychological well-being have remained unclear to date. Given the small amount of evidence found in two studies investigating psychological well-being as a secondary outcome and given the evidence from studies investigating the implementation of external step targets (Glynn et al., 2014; Goodyear et al., 2017; Maher et al., 2015), we hypothesized that

> **H1a**: Six weeks of fitness app usage will have neither a positive nor a negative effect on psychological well-being.

> **H1b**: The implementation of a daily step target of 10,000 steps will have a negative effect on psychological well-being.

With regard to the effects of fitness app usage and the implementation of external step targets on aspects of body awareness, empirical evidence is still lacking. However, based on descriptive and anecdotal work (Sharon & Zandbergen, 2017; van Dijk et al., 2015), it can be assumed that fitness app usage can enhance body awareness over time and that the implementation of an external step target can undermine listening to bodily states. Therefore, we hypothesized that

> **H2a**: Six weeks of fitness app usage will have a positive effect on aspects of body awareness.

> **H2b**: The implementation of a daily step target of 10,000 steps will have a negative effect on aspects of body awareness.

Methods

Trial Design

In this randomly controlled trial (RCT) study, two randomized experimental groups were implemented. Participants tracked their physical activity via a wearable fitness app device and a daily diary questionnaire. Participants allocated to the experimental target (ET) group had a predefined step goal of 10,000 steps per day implemented in the fitness app. Participants allocated to the experimental no target (ENT) group did not have any step goal (Figure 1). Participants in the additional control group did not receive a wearable fitness app device and tracked their

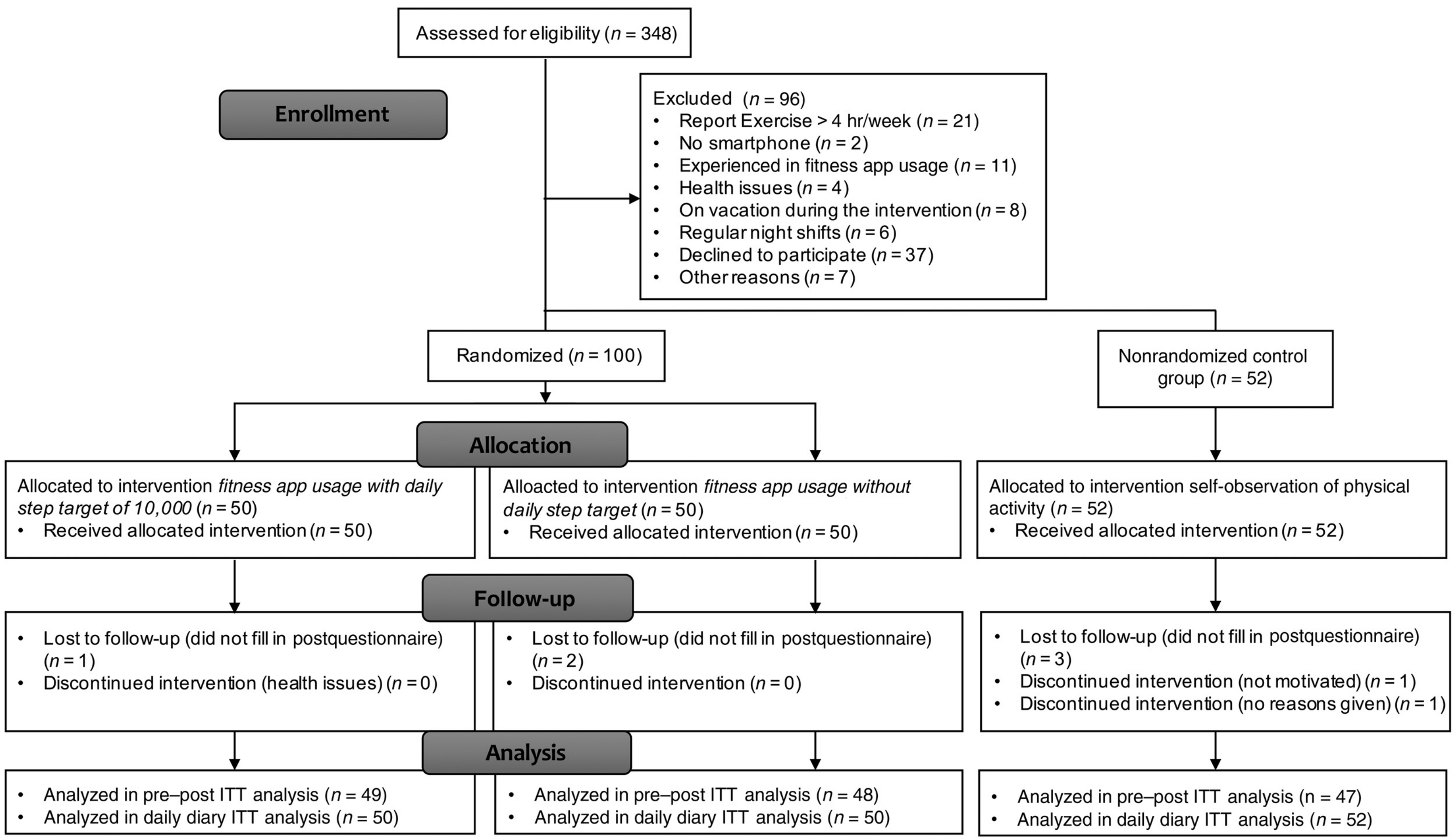

Figure 1 — Flow diagram guided by CONSORT. *Note*. The control group was not randomized or parallelized in order to ensure blinding to the study design. ITT = intention to treat.

physical activity—like all groups—via a daily diary. We used a multimethod approach to gain a comprehensive understanding of the interindividual and intraindividual trajectories, including the variance of outcomes. In addition to comprehensive prequestionnaires and postquestionnaires, a daily diary (experience sampling) method was applied. Experience sampling has been identified as a useful and elaborate technique with a large range of benefits, such as greater ecological validity, reduction in the likelihood of memory biases, and revelation of intraindividual processes (Bolger, Davis, & Rafaeli, 2003; Scollon, Prieto, & Diener, 2009). Following studies investigating the effects of fitness app usage (Walsh, Corbett, Hogan, Duggan, & McNamara, 2016; Wang et al., 2015), an intervention time of 6 weeks was determined.

Prior to recruitment, the study was approved by the ethics committee of the University of Münster. The study was registered at the German Clinical Trials Register (Grant no. DRKS00014835) and can be viewed on the WHO website http://apps.who.int/trialsearch/. All variables assessed (including the variables not used in this study) can be viewed there.

Conduct and reporting of the trial was guided by the Consolidated Standards of Reporting Trials (Schulz, Altman, & Moher, 2010).

Participants and Sample Size

Participants were recruited via flyers distributed at the University of Münster, via social media, and in local newspapers around the city of Münster. Participants for the control group were separately acquired during the same time period and in the same contexts using another flyer that was blind to the intervention (i.e., fitness tracker usage). Participants for the experimental groups were informed in advance that study participation would entail the use of a wearable fitness tracker and that this would result in the disclosure of personal data due to ethical considerations. To provide clear insight into the effects between the fully randomized ET and ENT groups and the control group, we provide two separate analyses: one including all three groups and one including only the two experimental groups (full results provided in the Supplementary Materials 1–7 [available online]). The participants were incentivized to participate as follows: every 20th participant completing the study won 20â‚¬, and each participating student enrolled at the University of Münster had the alternative opportunity to earn a credit of up to 5.5 hr.

In previous research, the effects of fitness app usage on body listening and body trusting have not been examined. In a 3-month intervention, medium effect sizes of meditation practice on body listening and body trusting were found (Bornemann, Herbert, Mehling, & Singer, 2015). Thus, an anticipated medium size effect of $f^2 = 0.18$ was estimated with regard to the expected increase in the outcome variables. A power analysis revealed that a sample size of $n = 45$ per group was required to detect a statistical effect of $f^2 = 0.18$, given 80% power, and $\alpha = .05$ (Soper, 2012). The dropout rate per group was estimated at 10%, but it was expected that the dropout rate in the control group receiving no fitness tracker would be higher compared with the experimental groups receiving a fitness tracker during the intervention. The plan was to recruit 50 participants per group, which was also defined in the preregistration at the DRKS. However, during the recruitment phase, 52 participants were allocated to Group 3 and were included in the intervention and analysis. The predefined inclusion criteria are presented in Table 1.

Group Allocation and Interventions

All allocated participants were invited to fill in a computer-based questionnaire under controlled lab conditions. The questionnaires were provided by the online survey program *unipark* (Questback GmbH, 2018). Weight and height were measured in the lab to calculate body mass index (BMI). All participants signed informed consent and were asked to contact the researchers in case of technical issues or health problems. The experimental groups received a wearable fitness tracker (*Fitbit Flex 2*) and instructions for fitness tracker usage. The participants' devices and smartphone applications were set up at the lab.

In the ET group, the daily step target was set to 10,000. In the ENT group, no daily step target was set; thus, the progress bar indicating daily steps did not change in the smartphone app. In both ET and ENT groups, the participants could also monitor calories burned, distance covered, and active minutes in the smartphone app. Participants in both groups were asked not to set further goals or change the app settings. During the 6-week intervention, the participants were asked to wear the fitness tracker wristband all day long. Every evening at 9pm, all participants received identical text messages with a link to an online daily diary.

After the 6-week intervention, all participants were invited to the lab to fill in the posttest computer-based questionnaire and return their device. The questionnaire entailed a check assessing whether the participants had worn the fitness trackers and whether they had changed the app settings during the intervention.

Blinding

All participants were blinded to the study design and the implementation of the different groups. After the study was completed, all participants were informed of the research questions and design. The researchers were not blinded to the experimental conditions or the purpose of the study. Management of the participants' data and generation of sequence allocation was conducted on the basis of the participants' codes and thus, the researchers were blinded to the participants' identities at this point. During the pretests and posttests and during the intervention, the researchers were in direct contact

Table 1 Inclusion Criteria

The participants
(a) are between 18 and 40 years old, representing the main age group using fitness apps (Statista, 2018).
(b) self-report exercise behavior of less than 4 hr/week on average to focus on participants who are not engaging in professional sport.
(c) have not used a fitness app for longer than 2 weeks within the past 6 months and thus represent fitness-app novices.
(d) possess a smartphone with Internet connection and bluetooth function.
(e) are currently not injured or diseased, reducing the risk of being in a state that can potentially influence the capability to exercise.
(f) are not planning to travel for more than 1 week during the study period.
(g) are not engaging in employment requiring night shifts on a regular basis to ensure valid daily measurement and analysis of the data.

with the participants (e.g., providing technical assistance). Thus, they were not blinded to the participants' identities or allocations at this point. During the analysis, all data were managed on the basis of the participants' codes. Thus again, the researchers were blinded to the participants' identities, but not to the participants' group allocations.

Outcomes

Psychological Well-Being. Well-being was measured via a German version of the WHO-5 questionnaire (Brähler, Mühlan, Albani, & Schmidt, 2007) using the word stem of the original questionnaire referring to the previous week. The questionnaire entails five items that are rated on a 6-point Likert scale 1 (*not agree at all)* to 6 (*fully agree*). Good reliability and validity of the German version of the WHO-5 have been demonstrated by Brähler et al. (2007). In the daily diary measurement, a single item measuring well-being was used (*I felt good today*) and rated on a 7-point Likert scale 1 (*not agree at all*) to 7 (*fully agree*).

Aspects of Body Awareness. Facing numerous approaches to measuring self-reported body awareness, a systematic review of the literature on measurements and concepts of self-reported body awareness was conducted (Mehling et al., 2009). In one study, a comprehensively validated questionnaire entailing all identified aspects of body awareness was established, that is, the multidimensional assessment of interoceptive awareness (Mehling et al., 2012). The scale *body listening* describes the exploration of and listening to body states. The scale *body trusting* refers to experiencing the body as safe and trustworthy.

In the pretest and posttest questionnaires, body listening and body trusting were measured via the German version of the multidimensional assessment of interoceptive awareness (Bornemann et al., 2015) on a 6-point Likert scale from 1 (*not agree at all*) to 6 (*fully agree*). Each scale included three items. In the daily diary questionnaire, single items were used to measure body listening (*I listened to my body today*) and body trusting (*I trusted my body today*) and were rated on a 7-point Likert scale from 1 (*not agree at all*) to 7 (*fully agree*).

Statistical Methods

It has been indicated that reactivity effects are likely to occur in pedometer-based studies during the first intervention week, especially during the first 3 days (Clemes & Deans, 2012). To rule out potential reactivity effects, the analyses of daily data were conducted excluding the first three intervention days. Furthermore, the data assessed in the daily diary at the posttest was excluded, as defined in the preregistration of this study. Thus, considering a 42-day intervention, daily diary data for 38 days were analyzed. All participants were considered in an intention-to-treat analysis. Data were screened for outliers and implausible data.

The reliability of each subscale was tested for the data assessed in the pretest as follows: First, the measurement model was identified, testing whether the congeneric or the essential τ-equivalent (equal loadings) unidimensional factor model fit the data better. Cronbach's α (1951) was used to estimate reliability for essential τ-equivalent measurement models. As Cronbach's α tends to overestimate coefficients for congeneric data (Zinbarg, Revelle, Yovel, & Li, 2005), McDonald's ω_H (McDonald, 1999) was conducted for congeneric models. To facilitate comparisons with other studies, Cronbach's α coefficients are presented but should not be interpreted. Bayesian linear regressions were conducted to tests potential group differences in baseline characteristics.

Main Analysis

To examine the main outcome variables across time and groups, ordinal Bayesian multilevel modeling was conducted, with longitudinal well-being, body listening, and body trusting as ordinal dependent variables. The ordinal models assumed the single-item Likert scores to be originating from the categorization of a latent continuous and normally distributed variable (Bürkner & Vuorre, 2019). This procedure not only facilitated interpretation but also ensured valid inference based on Likert scores, because classical analyses of such scores may have serious problems (Liddell & Kruschke, 2018). To account for potential heterogeneity, the latent variables' variances were modeled as varying across time and groups, with the variance of the control group at the initial time point being fixed at one for reasons of identification (Bürkner & Vuorre, 2019). In the models, intervention days were entered on Level 1, and person characteristics, including the group condition, were entered on Level 2. The time variable intervention days was scaled to only take on values between 0 (*first day*) and 1 (*last day*) in order to ease interpretation of regression coefficients. The grouping variable was dummy coded with the control group as reference category.

Similarly, pre–post data for body listening, body trusting, and well-being questionnaires were analyzed via ordinal Bayesian multilevel modeling using single-item Likert scores, while controlling for the dependency of observations belonging to the same item (Bürkner, 2017) because scales at pretest and posttest consisted of more than one item. Again, time of measurement was entered on Level 1, and person characteristics, including group condition, were entered on Level 2. Both time and grouping variable were dummy coded with pretest and control group being the reference categories, respectively. Latent variances were allowed to vary across time and groups in the same way as in the analysis of daily data. All analyses described above were conducted entering (a) all groups and (b) only the fully randomized ET and ENT groups (see Supplementary Materials 1–7 [available online]).

The results could have been biased due to some participants' properties varying systematically across groups, because the control group was not randomized. Therefore, controlling for potential effects, we entered the participants' age, gender, premeasured physical activity, BMI, and educational status as moderator variables in all analyses in order to at least partially account for nonrandomization. The moderator variables represent baseline characteristics that were assessed in order to evaluate the inclusion criteria and, therefore, were salient for the main research question. Furthermore, we considered BMI as a moderator variable, because a high BMI has been connected with body dissatisfaction or general health issues (Paxton, Neumark-Sztainer, Hannan, & Eisenberg, 2006; World Health Organization, 2017). Educational status was entered as an additional moderator variable, because preliminary analyses indicated that the percentage of students taking part in the control group was larger than the percentages in the experimental groups.

We also performed sensitivity analysis, in which we modeled the (latent) relationships of time and continuous person-related moderators (e.g., physical activity) with the outcome variables as nonlinear using two approaches: (a) by means of nonlinear smooth terms in the form of regression splines (Wood, 2003), and (b) by means of category specific effects, in which one regression coefficient per transition between two adjacent outcome categories was estimated instead of assuming a single regression coefficient constant across outcome categories (Bürkner, 2020; Bürkner &

Vuorre, 2019). We did not find any substantial nonlinear relationships; therefore, we report the related results only in the Supplementary Materials 1–7 (available online).

Data analyses were conducted using the programming language *R* (R Core Team, 2016) with the interface RStudio (RStudio Team, 2015). For the Bayesian multilevel analysis, the *R* package *brms* (Bürkner, 2017, 2018) based on Stan (Carpenter et al., 2017) was used. Normal priors with mean of 0 and *SD* of 2 were used for all regression coefficients, which can be considered only weakly informative given the scale of the predictor and latent response variable (Bürkner, 2017). For all other parameters, the default priors were used, which can be considered noninformative or weakly informative, having only minor influence on the obtained inference (Bürkner, 2017). The fully reproducible analysis, including open data and open code, of this study is provided on the Open Science Framework at https://osf.io/uz3e9/?view_only=a6b2691c5c08474ca0ff0d7f0626d2f5. The data linked to the primary outcome or any of the other secondary outcomes have not been published elsewhere.

Results

Participant Flow and Baseline Data

The recruitment period started on January 3, 2018, and ended after the predefined intervention time on June 5, 2018. The participant flow is presented in a flowchart guided by the consolidated standards of reporting trials criteria (Figure 1). In the ET and ENT groups, each 50 participants received the allocated intervention. In the control group, 52 persons participated. A total of $n = 7$ participants did not fill in the posttest questionnaire. Thus, the data for these participants could not be used for the pre–post analyses. In the ET group, one participant discontinued the intervention after 26 days due to health issues. In the control group, two participants discontinued the intervention at the day of the pretest and after 5 days without reasons given. However, all participants who discontinued the intervention were included in the intention-to-treat analysis. Thus, the data for all $N = 152$ participants were included in the multilevel daily diary analysis.

The baseline characteristics of the 152 participants measured in the pretest are presented in Table 2. In the ET group, 36 participants (72%) were female, and 32 participants (64%) were students. In the ENT group, 40 participants (80%) were female, and 33 participants (66%) were students. In the control group, 42 participants (81%) were female, and 49 participants (94%) were students. With regard to the randomized experimental groups, no differences in age, gender, physical activity, BMI, body trusting, body listening, and psychological well-being were observed. Comparing the additional control group with the other groups, no differences in physical activity, BMI, body trusting, body listening, and psychological well-being were observed. However, the control group was younger than the ET (95% credibility interval [CI] [1.08 to 4.59]) and ENT groups (95% CI [1.31 to 4.83]) (for details, see Supplementary Materials 1–7 [available online]). Participants in the control group reported lower trusting stance than participants in the ENT group (95% CI [0.03 to 1.05]).

Reliability of the psychological well-being scale was $\omega_H = 0.77$ (Cronbach's $\alpha = .76$) in the pretest questionnaire. A congeneric model fit the data better than an essentially τ-equivalent model in this study; $\Delta\chi^2(4) = 9.82$, $p = .044$. Thus, ω_H should be interpreted.

Reliability for the body listening scale was $\omega_H = 0.70$ (Cronbach's $\alpha = .68$) in the pretest questionnaire. A congeneric model fit the data better than an essentially τ-equivalent model in this study; $\Delta\chi^2(2) = 6.49, p = .039$. Thus, ω_H should be interpreted. For the body trusting scale, reliability was $\omega_H = 0.75$ (Cronbach's $\alpha = .74$) in the pretest. A congeneric model fit the data better than an essentially τ-equivalent model in this study; $\Delta\chi^2(2) = 13.65$, $p = .001$. Thus, ω_H should be interpreted. A comprehensive overview of the reliability scores for each condition at each test administration is provided in the Supplementary Materials 1–7 (available online).

Outcomes

In all analyses, moderator variables were entered for all pre–post and daily analyses on body listening, body trusting, and well-being in order to control for potential effects. Across all analyses of body trusting, age, gender, premeasured physical activity, BMI, and educational level had no influence on the observed effects. However, body listening was higher for females in the daily assessment ($b = 0.30$, 95% CI [0.02 to 0.60]) but not in the pre–post assessment. Well-being was higher in nonstudents in the pre–post assessment ($b = 0.55$, 95% CI [0.17 to 0.92]) but not in the daily assessment.

Daily Data. With regard to the analysis of body trusting and well-being across persons, no time, group, or time–group interaction effects were found. In the comparison of all groups, the ENT group reported lower body trusting than the control group at the beginning (see Table 3; for a visualization see Figure 2). Similarly, in the additional analysis with the comparison of only the ET and ENT groups (see Supplementary Materials 1–7 [available online]), no time, group, or time–group interaction effects were found.

The variation across persons in starting values (intercepts) and in changes over time (slopes) was high in all analyses (see Table 4).

Table 2 Baseline Characteristics Measured in the Pretest

		ET group ($n = 50$)		ENT group ($n = 50$)		Control group ($n = 52$)	
	Range	*M*	*SD*	*M*	*SD*	*M*	*SD*
Age (years)	18–40	25.56	4.54	25.78	4.78	22.73	4.32
Body mass index	17–32	22.33	3.11	22.14	2.86	21.74	3.18
Physical activity (hours per week)	0–4	2.21	1.28	2.23	1.09	2.58	1.15
Trusting stance in technology	1–7	4.79	1.07	4.87	1.34	4.31	1.41
Body listening	1–6	3.69	0.84	3.62	0.93	3.82	0.90
Body trusting	1–6	4.59	0.80	4.58	0.84	4.71	0.88
Well-being	1–6	3.73	0.83	3.66	0.78	3.66	0.79

Note. ENT = experimental no target; ET = experimental target.

Table 3 Results of the Multilevel Analyses of Well-Being, Body Listening, and Body Trusting Across Persons

	Daily measurement				Pre–post measurement			
	b	95% CI	$SD_{subjects}$	95% CI	*b*	95% CI	$SD_{subjects}$	95% CI
Well-being								
Intercept[a]	—	—	0.57	[0.47 to 0.68]	—	—	0.88	[0.72 to 1.06]
Time	0.13	[–0.14 to 0.41]	0.73	[0.58 to 0.90]	**0.49**	**[0.14 to 0.87]**	1.12	[0.90 to 1.37]
ET group	0.03	[–0.23 to 0.31]			0.02	[–0.37 to 0.40]		
ENT group	–0.18	[–0.45 to 0.09]			–0.05	[–0.46 to 0.37]		
Time:ET	–0.01	[–0.40 to 0.37]			–0.31	[–0.84 to 0.19]		
Time:ENT	0.11	[–0.28 to 0.51]			–0.46	[–1.01 to 0.05]		
Body listening								
Intercept[a]	—	—	0.66	[0.55 to 0.77]	—	—	0.97	[0.77 to 1.20]
Time	0.13	[–0.14 to 0.37]	0.63	[0.48 to 0.79]	0.12	[–0.12 to 0.37]	0.15	[0.01 to 0.40]
ET group	0.07	[–0.23 to 0.37]			–0.15	[–0.64 to 0.34]		
ENT group	**–0.35**	**[–0.66 to –0.03]**			–0.29	[–0.78 to 0.18]		
Time:ET	–0.17	[–0.54 to 0.19]			0.19	[–0.18 to 0.56]		
Time:ENT	–0.02	[–0.38 to 0.32]			–0.02	[–0.37 to 0.34]		
Body trusting								
Intercept[a]	—	—	0.67	[0.56 to 0.78]	—	—	1.23	[0.96 to 1.54]
Time	0.08	[–0.16 to 0.32]	0.62	[0.48 to 0.78]	0.08	[–0.24 to 0.41]	0.47	[0.04 to 0.85]
ET group	0.07	[–0.23 to 0.39]			–0.13	[–0.75 to 0.46]		
ENT group	–0.28	[–0.59 to 0.03]			–0.13	[–0.70 to 0.41]		
Time:ET	–0.18	[–0.52 to 0.15]			0.26	[–0.21 to 0.74]		
Time:ENT	0.05	[–0.31 to 0.39]			–0.19	[–0.67 to 0.24]		

Note. Regression coefficients whose credibility intervals do not include 0 are highlighted in bold. *b* = mean regression coefficient across persons; ENT = experimental no target; ET = experimental target; $SD_{subjects}$ = *SD* of the regression coefficient across persons; 95% CI = 95% credibility interval.
[a]Since ordinal models have multiple intercepts, for the sake of brevity we have not reported them.

Small negative correlations between intercepts and slopes were found in the analysis of well-being ($r = –.40$, 95% CI [–.58 to –.19]), body listening ($r = –.36$, 95% CI [–.56 to –.11]), and body trusting ($r = –.28$, 95% CI [–.49 to –.05]). In total, the variation of the outcomes decreased over time, although by a rather small amount, while no differences across groups were found (see Table 4).

Pre–Post Data. Targeting the pre–post data for body listening and body trusting, no time, group, or time–group interaction effects were found (see Table 3). For well-being, significant time effects were found. However, no group or time–group interaction effects were observed. Body listening measured in the pretest was negatively related to trusting stance in technology measured in the pretest ($b = –0.39$, 95% CI [–0.68 to –0.10]), and BMI ($b = –0.10$, 95% CI [–0.18 to –0.02]). Similarly, in the additional analysis comparing only the ET and ENT groups (see Supplementary Materials 1–7 [available online]), no group, time, or time–group interaction effects were found.

Discussion

It was the aim of this study to investigate the effects of 6 weeks of fitness app usage and the implementation of an external step target on psychological well-being and aspects of body awareness. To do so, we conducted a randomized controlled trial using a comprehensive multimethod analysis, analyzing the effects, interaction effects, and variation of psychological well-being and aspects of body awareness over time.

Well-Being

The WHO has defined mental health and psychological well-being as important factors for general health in their core principles (World Health Organization, 1995). Whereas the positive effects of the usage of fitness apps on physical activity have been stressed in a range of studies (Schoeppe et al., 2016), the effects of their use on quality of life have been analyzed in few studies to date. In the present study, no effects of fitness app usage on psychological well-being were found. Therefore, the results indicate that *Hypothesis 1a* can be confirmed. The results of this study indicate that neither fitness app usage nor the implementation of an external step target substantially affected psychological well-being during 6 weeks of fitness app usage. Aligned with the effects on well-being found in this study, an RCT investigating the effects of an 8-week online physical activity intervention including self-monitoring found improvement in walking time, but improvements in overall well-being and mental health were not found (Maher et al., 2015). In a similar RCT study, the effects of fitness app usage in primary care patients using fitness apps were examined (Glynn et al., 2014). After an 8-week intervention, improvement in step count was found, but well-being had not increased. By contrast, fitness app users in a sample of recreational runners reported higher levels of running activity, reported feeling better about themselves, and reported feeling more like an athlete (Dallinga, Mennes, Alpay, Bijwaard, & de la Faille-Deutekom, 2015). These results indicate that the effects of fitness app usage on psychological well-being may be task specific. In athletic persons, a specific activity can be of high value and connected to well-being. In contrast, in physically inactive persons, the personal value of physical activity may be of

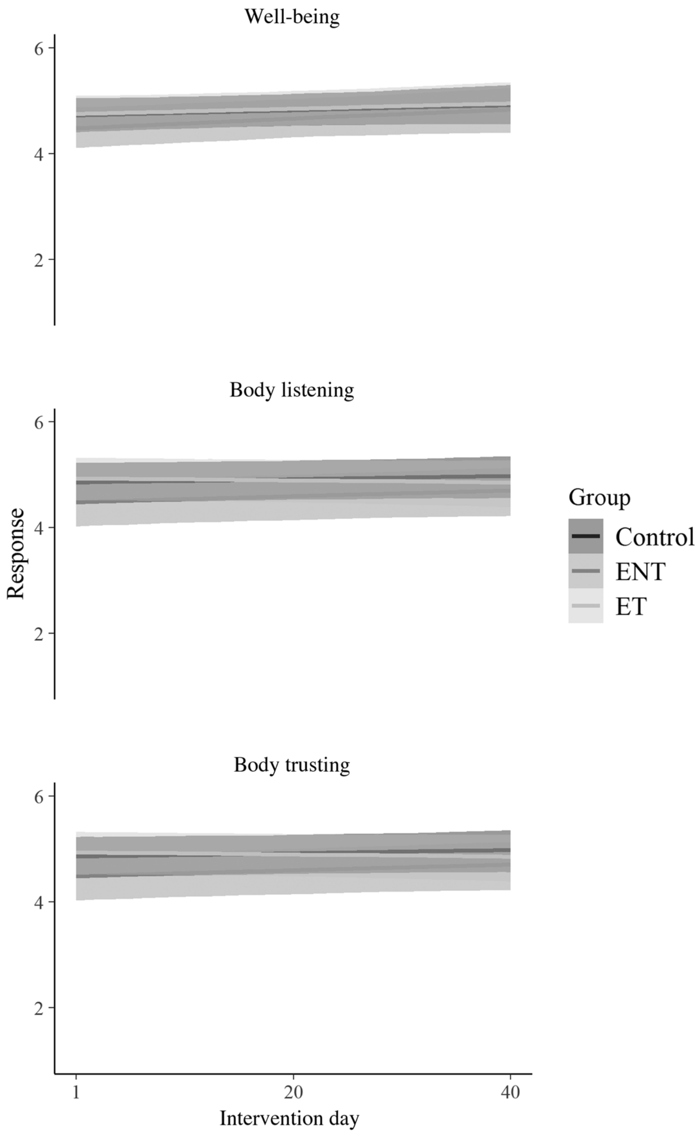

Figure 2 — Visualization of the daily analysis of well-being, body listening, and body trusting. *Note*. ENT = experimental no target; ET = experimental target.

lower relevance. Furthermore, it has been indicated that fitness apps scarcely target emotional aspects of physical activity and, therefore, neglect an important antecedent of physical activity (Forster et al., 2017). To gain a deeper understanding of the underlying processes, further studies should target psychological well-being across different samples using different and specific tasks. In this context, it has been highlighted that the effects of wearable activity monitors on physical activity may be specific to select cohorts (e.g., Lyons, Swartz, Lewis, Martinez, & Jennings, 2017; Matthews, Hagströmer, Pober, & Bowles, 2012) and that behavior change strategies embedded in many fitness apps may further support behavior change in select samples (Romeo et al., 2019; Schoeppe et al., 2016).

With regard to the effects of external step targets, no effects on psychological well-being were observed. Thus, the results indicate that *Hypothesis 1b* cannot be confirmed. These findings are in contrast to recent statements assuming that fitness app usage and the implementation of external step targets can produce pressure and fear of not meeting norms and standards (Lupton, 2013, 2014). However, it should be noted that a feeling of pressure or anxiety cannot be equated with a lack of the more comprehensive and general concept of psychological well-being. In sum, it is important to understand that the implementation of such step targets may provoke ambiguous or uncomfortable feelings in persons but does not seem to substantially threaten general psychological well-being in fitness app users.

Body Awareness

It was another aim of this study to investigate how fitness app usage can influence aspects of body awareness. The results of both the present daily and pre–post analyses in this study indicated no change during the 6-week intervention. Also, no group or time–group interaction effects were observed. The results indicate that neither self-observation of physical activity induced via a daily diary measurement nor the objective feedback provided by the app led to higher body listening or body trusting. Therefore, the results indicate that *Hypothesis 2a* cannot be confirmed. These findings are in contrast to the—to date—relatively descriptive and anecdotal discussion that fitness app usage can be regarded as a way to practice body awareness (Sharon & Zandbergen, 2017). Regarding empirical evidence, tracking physiological parameters has recently been associated with a higher correspondence of perceived stress and heart rate (van Dijk et al., 2015), in which physiological feedback such as heart rate can be observed and also regulated in direct and instant feedback. However, in contrast to the real-time tracking of heart rate, the tracking of one's own calories burned or steps covered represent ex post indicators of physical activity. Thus, the non-real-time feedback on physical activity in fitness apps may lack the capability to support calibration or better understanding of physiological processes. Thus, it appears unlikely that external feedback provided by the fitness app can influence body listening or body trusting, or that self-tracking via fitness apps could be regarded as a kind of calibration tool.

Furthermore, no effects of the implementation of a step target of 10,000 steps per day were found. Thus, the results indicate that *Hypothesis 2b* cannot be confirmed. Consequently, the results indicate that the implementation of an external step target might not have the potential to shift the attention from an internal focus to an external step target and, therefore, undermine the awareness of bodily states. Consequently, this first piece of empirical evidence connecting body awareness with fitness app usage yields to the conclusion that neither 6 weeks of fitness app usage nor the implementation of an external step target either promote or deteriorate aspects of body awareness.

Moderating Effects and Variation Across Time

In the moderator analyses, body listening measured in the pretest was negatively related to premeasured BMI. These results indicate that a high BMI may be associated with lower body trusting, because a high BMI has also been connected with body dissatisfaction or general health issues (Paxton et al., 2006; World Health Organization, 2017).

With regard to the analysis of variation across time, the variations across persons in starting values (intercepts) and in changes over time (slopes) were high in all analyses. The results indicate that the outcomes for fitness app usage were highly user specific and may

Table 4 Latent Outcome Variability Compared Across Groups and Time

	Daily measurement				Pre–post measurement			
	First day		Last day		Pretest		Posttest	
	σ	95% CI	σ	95% CI	σ	95% CI	σ	95% CI
Well-being								
Control group[a]	1	—	**0.86**	**[0.74 to 0.98]**	1	—	1.05	[0.88 to 1.25]
ET group	1.05	[0.94 to 1.18]	**0.86**	**[0.76 to 0.96]**	0.99	[0.82 to 1.16]	0.97	[0.82 to 1.15]
ENT group	0.99	[0.89 to 1.11]	**0.84**	**[0.75 to 0.95]**	1.05	[0.88 to 1.23]	0.99	[0.82 to 1.18]
Body listening								
Control group[a]	1	—	0.92	[0.79 to 1.06]			0.97	[0.77 to 1.21]
ET group	1.12	[0.99 to 1.26]	**0.85**	**[0.76 to 0.95]**	0.87	[0.70 to 1.08]	1.04	[0.83 to 1.28]
ENT group	1.10	[0.98 to 1.23]	**0.88**	**[0.78 to 0.99]**	1.12	[0.91 to 1.36]	1.08	[0.87 to 1.33]
Body trusting								
Control group[a]	1	—	0.89	[0.76 to 1.03]	1	—	1.03	[0.79 to 1.33]
ET group	1.02	[0.91 to 1.14]	**0.81**	**[0.72 to 0.91]**	**1.28**	**[1.01 to 1.59]**	**1.31**	**[1.03 to 1.65]**
ENT group	1.03	[0.91 to 1.15]	**0.75**	**[0.67 to 0.85]**	1.10	[0.86 to 1.37]	0.96	[0.76 to 1.22]

Note. *SD*s whose credibility intervals do not include 1 are highlighted in bold. ENT = experimental no target; ET = experimental target; σ = latent *SD* obtained from ordinal models varying across time and groups; 95% CI = 95% credibility interval of σ.
[a]The residual *SD* of the control group measured in the pretest was fixed at 1 for reasons of identifiability.

depend on a set of interindividual and contextual factors. To gain a deeper understanding of the trajectories of body listening, body trusting, and well-being, the residual variability of outcomes across time and groups was analyzed as well. In the daily analyses, the residual variation decreased slightly over time but did not vary across groups. Thus, the participants' responses were more predictable at the end of the study than at the start, which may be a result of the participants answering more consistently due to increased experience with the study procedures (i.e., questionnaires). Such a decrease in residual variation over time was not found in the pre–post analyses. Rather, the residual *SD* for body trusting differed slightly across groups without a notable change from premeasurement to postmeasurement.

Strengths and Limitations

In this study, the effects of fitness app usage and the implementation of a specific external step target were examined in a multimethod approach. In addition to comprehensive prequestionnaires and postquestionnaires, the outcome variables were assessed via an experience sampling method, using state-oriented items (e.g., *I listened to my body today*). Thus, comprehensive analysis of the trajectories and variability of the outcome variables was possible. Overall, high variability across time and persons was observed and could not be explained by the moderators we assessed. Thus, the trajectories and potential influencing factors on variability in well-being and aspects of body awareness are still unclear. To shed light on these processes, it is of high interest to identify more potential influences moderating the effects of fitness app usage (e.g., personal preferences and goals, familiarity with apps, etc.) via exploratory quantitative methods but also via qualitative methods.

Considering the intervention time of 6 weeks of app usage together with the lack of effects on psychological well-being and body awareness found in this study, it can be assumed that this time period was too short to observe long-time effects. Nevertheless, previous research has indicated that aspects of body awareness can be subject to effective intervention studies. For example, it has been indicated that aspects of body awareness can be improved after a 12-week meditation intervention (Bornemann et al., 2015). However, the analysis of meta-analytical data has indicated that participants' adherence to fitness app intervention studies dramatically decreases after 5–6 weeks of intervention time (Schoeppe et al., 2016). Considering the expected increase in dropout after 5–6 weeks and according to previous studies investigating the effects of fitness app usage, we decided to define an intervention time of 6 weeks.

In this study, we examined the effects of self-tracking via fitness apps in fitness app novices. The explicit exclusion criterion was defined that the participants had no history in tracking their physical activity via a fitness app for more than 2 weeks within the past 6 months (see Table 1). However, it was not considered whether the participants had regularly monitored their physical activity via other means, such as paper and pencil. With regard to the randomization process, the two experimental groups, ENT and ET, were fully randomized, and the procedure met all criteria for RCTs set forth in the consolidated standards of reporting trials statement (Schulz et al., 2010). The control group was separately acquired but was acquired during the same time period and in the same contexts using another flyer that was blind to the intervention (i.e., fitness tracker usage). Alternatively, all three groups could have been randomized and provided with the information that they might or might not receive a fitness tracker. However, it was expected that the group not being provided with a fitness tracker may have perceived inferiority to the fitness tracker groups, potentially leading to undesired and uncontrollable group effects. Therefore, it was an advantage of the study that all participants were blinded to the study design. Considering hypothetical biases across groups, we attempted to control for potentially relevant variables (i.e., age, gender, educational status). However, potential specific group effects influencing the results cannot be fully excluded. Furthermore, few premeasured differences (i.e., in body listening) were observed. Overall, future studies following a similar study design could investigate the effects and sample distributions in a completely randomized design, informing all participants that the study might or might not include fitness app wearable usage.

Despite participants being blinded to their group assignments and experimental groups being randomly assigned, there is still potential for postrandomization confounding for the experimental groups. Postrandomization confounding could have occurred due to selective dropout, missing not-at-random data, or participant-related factors that have differential effects for the different groups. We tried to account for such patterns by modeling heteroscedastic errors and estimating group-specific nonlinear effects in a sensitivity analysis. However, despite our efforts, one can never rule out postrandomization confounding entirely.

Implications and Conclusion

This study was designed to gain a broader understanding of the benefits and risks of fitness app usage, specifically with regard to the implementation of a specific external step target on psychological well-being and aspects of self-reported body-awareness. The results of this study contribute to a small but growing body of evidence indicating that fitness app usage does not influence psychological well-being. Furthermore, this study was the first to investigate potential effects of fitness app usage on body listening and body trusting. Further studies are needed to underpin these results, especially with regard to aspects of body awareness and other nonphysical health outcomes. Considering the large variability in effects, potential positive effects can be assumed under specific conditions that are to be identified in further studies. To support the beneficial effects of fitness app usage on physical activity, app developers might lay a pronounced focus on promoting a great range of specific app functions. These settings could be designed to satisfy diverse and individual user specific needs and preferences. For instance, a recreational runner might benefit from app functions complementing his or her exercise-related preferences, whereas a physically inactive person would benefit from other settings that better match his or her needs, needs that should be identified in future studies. In summary, the results indicate that fitness app usage—specifically, the tracking of steps and calories burned—neither supports nor deteriorates overall psychological well-being, body listening, or body trusting over a 6-week time period. However, a large variability in effects was observed, indicating that the effects of fitness app usage are highly individual.

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