**A Daily Diary of the Quantified Self – The Influence of Fitness App Usage on
Psychological Well-Being, Body Listening and Body Trusting**

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Abstract

Continuous self-tracking via fitness apps has become popular and has been described as a way of practicing body awareness. Many app providers have implemented a daily step target option in the app. 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 are still unclear. It was the aim of this study to examine these effects and to explore causal relationships between body trusting and well-being.

Novice fitness app users (Age: $M = 24.66$ years ranging from 18–40 years) were recruited. Two randomized groups (each $n = 50$) used a fitness tracker device for six weeks. One group was provided with a pre-defined target of 10,000 steps per day, whereas the second group was not. A third control group ($n = 52$) documented their daily physical activity. A daily diary method was used to measure well-being, body listening and body trusting.

In Bayesian multilevel analyses, we found neither time nor group-time interaction effects. These results were robust when controlling for a range of variables (e.g., physical activity, age). Longitudinal connections between body trusting and well-being were observed, however varying when controlling for auto-correlation.

We concluded that exercise-related self-tracking via fitness app usage and specific external step goals does not substantially influence psychological well-being, body trusting and body listening. Considering the large variability in effects, potential positive effects can be assumed under specific conditions that are to be identified in further studies.

Keywords: Fitness App, Body Awareness, Well-being, RCT, Daily Diary

Introduction

Fitness smartphone applications (apps) that are designed to support health behaviour are currently very popular: In an international representative survey, 33% of the participants stated to currently track their physical activity via one or more smartphone applications¹. Fitness apps can be combined with matching wearables (e.g., wristbands) and often provide options that deliver information about one's own step count, number of burnt calories, heart rate etc.^{2,3}. Thus, fitness apps are able to offer objective feedback and detailed information about body-related states and processes. To encourage their customers to often use their app, many fitness app providers have also implemented an option 'daily step target' (e.g., 10,000 steps per day) into the app settings that can be continuously compared to the current actual step count. Within the past years, tracking of body-related parameters via fitness apps has contributed to the establishment of a lifestyle that has been named *the quantified self*^{4,5}. Previous research has indicated that tracking body-related data contributes to supporting self-care and health related habit development^{6,7}.

The World Health Organisation (WHO) has emphasised mental and social well-being next to physical health as important factors of general health in their core principles⁸. Moreover, mental health and psychological well-being have been identified as key priorities in the WHO Sustainable Development Goals, assuming to contribute to have a positive impact on communities around the world⁹. In the field of fitness app usage, researchers have started to investigate the outcomes of fitness app usage, however, mostly with a focus on the outcomes related to physical health¹⁰. It has been shown that fitness app usage can foster higher activity levels, for instance, step counts¹⁰⁻¹². The outcomes of fitness app usage (i.e., tracking of body-related data) on mental states and mental health (i.e., evaluation of and attention to body states, psychological well-being) have yet to be focused as main research questions. Subsequently, it is of urgent interest to investigate the effects of fitness app usage on mental and social well-being additionally to physical health.

Self-Tracking and Body Awareness

Monitoring oneself via technical devices (i.e., fitness apps) has been described as a way of practicing body awareness¹³. Body awareness is a multi-faceted concept that is used across different fields, including psychology, medicine, and sport and exercise sciences^{14–16}. Body awareness has been conceptualized diversely (e.g., as interoceptive awareness, body awareness, mindfulness¹⁷). Across scholars, high levels of body awareness are considered to be beneficial: Body awareness has been associated with higher ability to register body sensations¹⁸ and with psychological well-being^{19,20}. 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 pain¹⁷). After a three months training program that targeted interoceptive awareness via meditation practice, measures of attention regulation, emotional awareness, self-regulation, body listening, and trusting increased compared to a re-test control group²¹

In the field of sport and exercise science, higher levels of body awareness were found in athletes compared to non-athletes²² and in advanced yoga and Pilates practitioners compared to beginners²³. Body awareness was also identified as a training component that can reduce risk factors of physical injury in sports²⁴. Body knowledge can lead to higher body trust and modify the exercise process based on body sensations²⁵ or to more physical activity in children²⁶. In a relaxation intervention that targeted body awareness in taekwondo athletes, positive effects on the athletes' performance were found²⁷. In sum, tracking one's own physiological parameters is related to a higher correspondence of perceived stress and objective measures of heart rate²⁸. Therefore, it has been discussed that self-tracking might be able to contribute to the enhancement of body awareness.

Goal Setting

One central function of numerous fitness apps and wearables is a step count that is often combined with an option for a step target³. Following the recommended levels of physical activity²⁹, many wearable providers have implemented a specific pre-defined target of 10,000 steps per day in the app settings. Goal setting has been examined from a range of

theoretical approaches and in diverse contexts^{30,31}. From goal setting theory perspective³², it is assumed that task progress in goal reaching can lead to higher levels of well-being³⁰. From Self-Determination Theory perspective^{30,31}, intrinsic goals can lead to higher levels of well-being, whereas external goals are associated with lower levels of autonomous motivation and well-being³³.

The Present Research

Continuous self-tracking and the implementation of a pre-set step target 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 yet to be examined. Specifically, it is unclear how and if continuous self-monitoring of one's own physical activity level influences the effects on self-reported capability to listen to body states, and how specific goal setting (i.e., 10,000 steps per day) is related to psychological well-being. In addition, it is not yet understood how body trusting is related to well-being.

Based on previous research^{13,28}, it can be assumed that objective feedback that is provided by the fitness app enhances individuals' body listening and body trusting over time. However, it is unclear if goals set in the fitness app can also undermine listening to body states. From goal setting theory perspective³⁰, goal setting in one group is assumed to lead to higher levels of well-being compared to a condition with no implementation of a specific step target.

Based on current recommendations in fitness app research¹⁰, it is crucial to test specific apps and its functions under controlled conditions. Therefore, we aimed at examining two groups using a fitness app device under randomized controlled conditions. We aimed at systematically varying the condition by implementing a specific step target in one group (i.e., 10,000 steps per day) to understand the effect of this specific app function.

Furthermore, we aimed at understanding the process of continuous self-monitoring via fitness apps by observing potential longitudinal effects in both groups. To provide a better

understanding of the general vs. fitness app specific processes associated with continuous self-monitoring, we aimed at 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. In connection with the potential effects of fitness app usage on body listening, body trusting and well-being, it can be highly relevant to consider whether a fitness app user trusts the feedback provided by the fitness app. Therefore, supplementary analyses targeting the mediating role of trust in technology are provided (See Online Supplement). Furthermore, it was the aim to explore potential causal relationships between body trusting and psychological well-being. To answer these questions, we aimed at using a multi-method approach to gain a comprehensive understanding of the inter- and intraindividual trajectories including the outcomes' variance. In addition to comprehensive pre- and post-questionnaires, we aimed at conducting daily assessment (i.e., experience sampling). Experience sampling has been identified as a useful and elaborate technique with a large range of benefits (e.g., greater ecological validity, reduction in the likelihood of memory biases, revelation on intra-individual processes)^{34,35}.

Results

Participant Flow and Baseline Data

The recruitment period started on 3rd January 2018 and ended after the pre-defined intervention time on 5th June 2018. The participant flow is presented in a flow-chart guided by the CONSORT criteria³⁶ (Figure 1). In the Experimental Target (ET) and Experimental No Target (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 post-test questionnaire. Thus, the data of 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 pre-test and after five days without reasons given. However, all participants who discontinued

the intervention were included in the intention-to-treat analysis. Thus, the data of all $n = 152$ participants were included in the multilevel daily diary analysis.

-- place Figure 1 near here --

The baseline characteristics of the 152 participants measured in the pre-test are presented in Table 1. 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 regards to the randomized experimental groups, no differences in age, trusting stance, physical activity, BMI, body trusting, body listening, and psychological well-being were observed. In comparison of 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%-CI = [1.08, 4.59]) and ENT groups (95%-CI = [1.31, 4.83]) (details see Online Supplement). Furthermore, the control group reported lower levels of trusting stance than the ENT group (95%-CI = [0.03, 1.05]).

-- place Table 1 near here --

Outcomes

In all analyses, moderator variables were entered for all pre-post and daily analyses on body listening, body trusting, and well-being to control for potential effects. Here, for all tested variables (i.e., trusting stance in technology, pre-measured physical activity and BMI), no substantial effects were observed (see Online Supplement). Across all analyses of body trusting, age, gender, and education level had no influence on the observed effects. However, body listening was higher in females in the daily assessment ($b = 0.30$, 95%-CI = [0.02, 0.60]), but not in the pre-post assessment. Well-being was higher in non-students in the pre-post assessment ($b = 0.55$, 95%-CI = [0.17, 0.92]), but not in the daily assessment.

Daily data. With regards to the analysis of body trusting and well-being across persons, neither time effects nor time-group interaction effects were found. In comparison of

all groups, the ENT group reported lower body trusting compared to the control group at the beginning (see Table 2, for a visualization see Figure 2). However, no time or time-group interaction effects were observed. An additional analysis facing the comparison of only ET and ENT groups is provided (see Supplement C). Here, the ET group reported higher levels of body trusting and body listening compared to the ENT group at the beginning. Overall, the variation across persons in starting values (intercepts) and in changes over time (slopes) were high in all analyses (see Table 2). Small negative correlations between intercepts and slopes were found in the analysis of well-being ($r = -.40$, 95%-CI = $[-.58, -.19]$), body listening ($r = -.36$, 95%-CI = $[-.56, -.11]$), and body trusting ($r = -.28$, 95%-CI = $[-.49, -.05]$). 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 3).

-- place Figure 2 near here --

-- place Table 2 near here --

Pre-post data. Targeting the pre-post data of body listening and body trusting, again neither time nor group effects or group-time interaction effects on were found (see Table 2). For well-being, significant time effects were found. However, no group or group-time interaction effects were observed. Body listening measured in the pre-test was negatively related to pre-measured trusting stance in technology ($b = -0.39$, 95%-CI = $[-0.68, -0.10]$), and BMI ($b = -0.10$, 95%-CI = $[-0.18, -0.02]$). In the additional analysis facing the comparison of only ET and ENT groups (see Supplement C), again neither group nor time or time-group interaction effects were found.

-- place Table 3 near here --

Ancillary analyses. Further analyses targeted potential causal effects via a cross-lagged analysis. When not controlling for auto-correlation, body trusting was positively related to well-being one day later ($b = 0.06$, 95%-CI = $[0.03, 0.10]$) and, vice versa, well-being was also positively related to body trusting one day after ($b = 0.07$, 95%-CI = $[0.03, 0.10]$). However, after controlling for lag-one auto-correlation, well-being was unrelated to

body trusting one day after ($b = 0.00$, 95%-CI = $[-0.04, 0.05]$), whereas body trusting was negatively related to well-being one day after ($b = -0.07$, 95%-CI = $[-0.12, -0.02]$). The lag-one auto-correlation coefficient for body trusting was $b = 0.12$ (95%-CI = $[0.07, 0.17]$), and $b = 0.23$ (95%-CI = $[0.18, 0.28]$ for well-being, thus demonstrating a somewhat stronger auto-correlation for well-being.

Discussion

The World Health Organisation (WHO) has defined mental health and psychological well-being as important factors of general health in their core principles⁸. Whereas the positive effects of fitness app usage on physical activity have been stressed in a range of studies¹⁰, the effects on quality of life were analysed in few studies to date. The results of this study indicate that neither self-monitoring of physical activity via fitness apps nor the implementation of an external step target substantially affects psychological well-being during six-weeks of fitness app usage.

Aligned with the effects on well-being found in this study, an RCT investigating the effects of an eight week online physical activity intervention including self-monitoring found improvement in walking time, whereas improvements in overall well-being and mental health were not found respectively¹². In a similar RCT study, the effects of fitness app usage in primary care patients using fitness apps were examined¹¹. After the eight weeks intervention, improvement in step count was found, but well-being had not increased either. In contrast, fitness app users in a sample of recreational runners reported higher levels of running activity, reported feeling better about themselves, and feeling more like an athlete³⁰. These results indicate that the effects of fitness app usage on psychological well-being can be task specific. In active and sportive persons, the specific activity can be of high valence and connected to well-being. However, in non-sportive persons, physical activity might be of lower relevance. From goal setting perspective, the results yield to the conclusion that extrinsic goals implemented in the app cannot lead to higher levels of well-being, supporting assumptions postulated by Deci and Ryan³³. To gain a deeper understanding of the underlying processes,

further studies should target psychological well-being across different samples using different tasks such as specific tasks.

It was another main aim of this study to investigate how self-monitoring of physical activity via fitness apps can influence aspects of self-reported body awareness. It has been outlined that abilities in body listening, body awareness and body regulation can be beneficial for improving health conditions and pain management^{17,38}, and have been associated with higher levels of subjective well-being¹⁹. Furthermore, it has been discussed that fitness app usage can be regarded as a way to practice mindfulness and body awareness¹³. However, the results of the daily as well as pre-post analyses regarding body listening and body trusting indicated no change during the six-weeks intervention at all. No group effects and no group-time 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 levels of self-reported body listening or body trusting across the participants.

Tracking physiological parameters has also been associated to a higher correspondence of perceived stress and heart rate²⁸. Physiological feedback such as heart rate can be observed and also regulated in direct and instant feedback. However, tracking of one's own burnt calories or covered steps represent an ex-post indicator of physical activity and might not be helpful in calibration or better understanding of physiological processes. Thus, it might be unlikely that external feedback provided by the fitness app can influence body listening and body trusting.

In ancillary analyses targeting the moderating effects of stance in technology, physical activity, or BMI, no effects were found over time. The results indicate that the trajectories of body listening, body trusting and well-being over time are neither influenced by whether a person trusts the feedback provided by the app, nor by their body constitution or physical activity. However, body listening measured in the pre-test was negatively related to pre-measured trusting stance in technology and BMI. These results indicate that a high BMI can

be associated with lower body trusting, as a high BMI might also potentially lead to health risks and dissatisfaction with the body^{39,40}. Additionally, low body trusting might make a person lay higher trust in body related feedback provided by fitness apps and thus report higher trust in such gadgets.

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 of fitness app usage are highly user specific and might depend on a set of inter-individual and contextual factors. To gain a deeper understanding of the trajectories of body listening, body trusting and well-being, the residual variability of the outcomes across time and groups was analysed as well. In the daily analyses, the residual variation decreased slightly over time but did not vary across groups. Thus, participants' responses were better predictable at the end of the study than at the start, which may be a result of 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. Instead, the residual standard deviation in body trusting differed slightly across groups without a notable change from pre- to post-measurement.

In alignment with the results of a range of other studies^{19,20}, body trusting was found to be associated with future well-being in this study. When not controlling for auto-correlation in daily well-being and body trusting, well-being was positively associated with body trusting one day after and, vice versa, body trusting was positively associated with well-being one day after. However, when controlling for auto-correlation via cross-lagged analyses to explore potential causal effects of body trusting on well-being (and vice versa), well-being was unrelated to body trusting one day after, while body trusting was slightly negatively related to well-being one day after. One explanation for the latter finding is that besides aspects of well-being, body trusting might also include aspects of less positive valence that might be negatively associated with well-being and thus lead to a negative effect when controlling for well-being in body trusting. In summary, we found a clear connection between body trusting

and well-being, however, the exact nature of this connection still remains uncertain and needs to be explored in further studies with even more complex designs.

In this study, the effects of fitness app usage and the implementation of a specific external step target were examined in a multi-method approach. In addition to comprehensive pre- and post-questionnaires, 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 the variability in well-being and aspects of body awareness are still unclear. To shed light into these processes, it can be 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 but also via qualitative methods.

To examine the main outcome variables across time and groups, ordinal Bayesian multilevel modelling was conducted. The ordinal models assume the single item Likert-scores to be originating from the categorization of a latent continuous and normally distributed variable⁴¹. This procedure not only facilitates interpretation, but also ensures valid inference based on Likert-scores, as classical analyses of such scores may have serious problems⁴².

The two experimental ENT and ET groups were fully randomized, and the procedure met all criteria set for RCTs set forth in the CONSORT statement³⁶. The control group was separately acquired – however at 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 thus been provided with the same 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 could 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 for 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 pre-measured differences (i.e., in body listening) were observed. To provide clear insight in 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. Participants of the experimental groups were informed in advance that the 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. 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.

This study was designed to gain a broader understanding of the benefit of fitness app usage and 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 research indicating that fitness app usage does not influence psychological well-being and is the first to investigate potential effects on body listening and body trusting. Further studies are needed to underpin these results especially with regard aspects of body awareness and other non-physical 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. Supporting these 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 their needs that need to be identified in future studies. Overall, the results indicate that fitness app usage—and specifically tracking of steps and burnt calories—cannot support the overall improvement of

psychological well-being, body listening or body trusting. However, a large variability in effects was observed, indicating that the effects of fitness app usage are highly individual.

Methods

Trial Design

In this study, two randomized experimental groups tracked their physical activity via a wearable fitness app device and a daily diary questionnaire. The ET group had a pre-defined step goal of 10,000 steps per day implemented in the fitness app, whereas the ENT group did not have any step goal (Figure 1). The control group did not receive a wearable fitness app device and tracked their physical activity — like all groups — via a daily diary. In addition to comprehensive pre- and post-questionnaires, a daily diary (experience sampling) method was applied. According to studies investigating the effects of fitness app usage^{43,44}, an intervention time of six 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). Conduct and reporting of the trial was guided by the Consolidated Standards of Reporting Trials (CONSORT)³⁶.

Participants and Sample Size

Participants were recruited via flyers distributed at the university, via social media, and local newspapers around the city of Münster. The flyer version to recruit the control group did not entail any information about the fact that some groups would receive fitness trackers during the study. The participants were incentivised to participate as follows. Every 20th participant completing the study won 20€. Each participating student enrolled at the university of Münster had the alternative opportunity to earn a credit of up to 5.5 hours.

The effects of fitness app usage on body listening and body trusting have yet to be examined. In a three month intervention, medium effect sizes of meditation practice on body listening and body trusting were found²¹. Thus, an anticipated medium size effect of $f^2 = .18$

was estimated with regards 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 $f^2 = .18$, given 80% power, and $\alpha = .05^{45}$. The dropout rate per group was estimated 10%, whereas it was expected that the dropout rate in the control group receiving no fitness tracker would be higher compared to the experimental groups receiving a fitness tracker during the intervention. It was planned to recruit 50 participants per group, which was also defined in the pre-registration. However, during the recruitment phase, 52 participants were allocated to Group 3 and thus were included in the intervention and analysis. The pre-defined inclusion criteria are presented in Table 4.

-- place Table 4 near here --

Group Allocation and Interventions

After randomization of the two experimental groups, 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*⁴⁶. Weight and height were measured in the lab to calculate the BMI. All participants signed informed consent and were asked to contact the researchers in case of technical issues or health problems. The experimental groups additionally received a fitness tracker wearable (*Fitbit Flex 2*) and instructions targeting the fitness tracker usage. The participants' devices and the smartphone application were set up at the lab.

In the ET group, the daily step target was set to 10,000, whereas in the ENT group, no daily step target was set. Thus, the progress bar indicating the daily covered steps did not change in the smartphone app. In both ET and ENT groups, the participants could also monitor their burnt calories, covered distance, 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 six-weeks intervention, the participants were asked to wear the fitness tracker wristband all day long. Every evening at 9pm, all participants received identical text messages entailing a link to an online daily diary.

After the six-week intervention, all participants were invited to the lab to fill in the post-test computer-based questionnaire and to 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 for the study design and the implementation of different groups. After the study was completed, all participants were informed about the research questions and design. The researchers were not blinded for 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. Thus, the researchers were blinded for the participants' identity. The researchers were in direct contact with the participants (e.g., providing technical assistance) during the pre- and post-tests and the intervention. Thus, they were not blinded for the participants' identity or allocation. During the analysis, all data was managed on the basis of the participants' code. Thus again, the researchers were blinded for the participants' identity, but not the participants' group allocation.

Outcomes

Psychological Well-Being. Well-being was measured via a German version of the WHO-5 questionnaire⁴⁵. 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 has been demonstrated⁴⁷. Reliability in the Pre-Test questionnaire was $\omega_H = .77$ (Cronbach's $\alpha = .76$) A congeneric model fit the data better compared to an essentially τ -equivalent model in this study; $\Delta\chi^2(4) = 9.82, p = .044$, and thus, ω_H should be interpreted. 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*).

Body Trusting and Body Listening. Beyond the background of numerous approaches measuring self-reported body awareness, a systematic review of the literature on

the measurements and concepts of self-reported body awareness was conducted¹⁷. In a further study, a comprehensively validated questionnaire entailing all identified aspects of body awareness was established⁴⁸. The scale *body listening* describes the exploration and listening to body states. The scale *trusting* refers to experiencing the body as safe and trustworthy.

In the pre- and post-intervention questionnaires, body listening and body trusting were measured via the German version of the Multidimensional Assessment of Interoceptive Awareness²¹ on a 6-point Likert scale (1 = *not agree at all* to 6 = *fully agree*). Each scale includes 3 items. Reliability in the pre-test questionnaire was $\omega_H = .70$ (Cronbach's $\alpha = .68$) for body listening. A congeneric model fit the data better compared to an essentially τ -equivalent model in this study; $\Delta\chi^2(2) = 6.49, p = .039$, and thus, ω_H should be interpreted. For body trusting, reliability in the pre-test was $\omega_H = .75$ (Cronbach's $\alpha = .74$). A congeneric model fit the data better compared to an essentially τ -equivalent model in this study; $\Delta\chi^2(2) = 13.65, p = .001$, and thus, ω_H should be interpreted. In the daily diary questionnaire, single items were used to measure body listening ("*I listened to my body today*") and body trust ("*I trusted my body today*") and were rated on a 7-point Likert scale (1 = *not agree at all* to 7 = *fully agree*).

Statistical Methods

Preliminary Analysis and Data Management. To rule out potential reactivity effects, the analyses of daily data were conducted excluding the first three intervention days. Furthermore, the incomplete day of measurement at the post-test was excluded, as it was defined in the pre-registration of this study. Thus, considering a 42 days intervention, daily diary data of 38 days was analysed. All participants were considered in an intention-to-treat (ITT) analysis. Data were screened for outliers and implausible data.

The reliability of each subscale was tested for the data assessed in the pre-test 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 was used to estimate the reliability for essential τ -equivalent measurement models. As Cronbach's α tends to overestimate coefficients for congeneric data⁴⁹, McDonald's ω_H ⁵⁰ was conducted for congeneric models. To facilitate comparisons with other studies, Cronbach's α coefficients are presented additionally, 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 modelling was conducted, with longitudinal body listening, body trusting, and well-being as ordinal dependent variables. To account for potential heterogeneity, latent variables' variances were modelled 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 identification⁵¹. 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) to ease interpretation of regression coefficients. The grouping variable was dummy coded with the control group as reference category.

Similarly, pre-post data of body listening, body trusting, and well-being questionnaires were analysed via ordinal Bayesian multilevel modelling using single item Likert-scores, while controlling for the dependency of observations belonging to the same item⁵¹ as scales at pre- and post-treatment 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 pre-test 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; (b) only the randomized ET and ENT groups (see Online Supplement).

In further exploratory analyses, all analyses described above were conducted, each entering the moderator variables trusting stance in technology, pre-measured physical activity, and BMI. Additionally, exploring potential causal effects between body trusting and well-being, each variable was entered and regressed on the predictor variable measured one day earlier, thus controlling for auto-correlation. The results could have potentially been biased due to some participants' properties varying systematically across groups as the control group was not randomised. Therefore, we controlled for participants' age, gender, and educational status in all analyses in the hope to at least partially account for non-randomization.

Data analyses were conducted via the programming language *R*⁵² with the interface RStudio⁵³. For the Bayesian multilevel analysis, the R package *brms*⁵¹ based on Stan⁵⁴ was used. Normal priors with mean 0 and standard deviation 2 were used for all regression coefficients, which can be considered only weakly-informative given the scale of the predictor and latent response variable⁵¹. For all other parameters, the default priors are used, which can be considered non- or weakly informative, thus having only minor influence on the obtained inference⁵¹. The fully reproducible analysis including open data and open code of this study is provided on OSF

https://osf.io/uz3e9/?view_only=a6b2691c5c08474ca0ff0d7f0626d2f5.

Author Contributions

L.B. conceptualized the study throughout the whole process. L.B. developed the research design, conducted and managed the data acquisition, was responsible for pre-registration, ethical approval and conduction of the trial, statistical analysis, drafted the manuscript and approved the final manuscript as submitted.

T.U. participated during the whole study process. T.U. contributed to the development of the research design, the pre-registration, ethical approval and conduction, and provided assistance with the statistical analysis, writing and critically reviewing the manuscript and approved the final manuscript as submitted.

P.-C.B. led the statistical analyses, participated in writing critically reviewed the manuscript and approved the final manuscript as submitted.

B.S. contributed to the study design, critically reviewed the manuscript and approved the final manuscript as submitted

All authors approved the final manuscript as submitted and agreed to be accountable for all aspects of the work.

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Table 1
Baseline Characteristics Measured in the Pre-Test

	Range	Group 1 (<i>n</i> = 50)		Group 2 (<i>n</i> = 50)		Group 3 (<i>n</i> = 52)	
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Age (years)	18–40	25.56	4.54	25.78	4.78	22.73	4.32
Body mass index (BMI)	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. *M* = mean; *SD* = standard deviation.

Table 2

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

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

Note. *b* = mean regression coefficient across persons; *SD*_{subjects} = standard deviation of the regression coefficient across persons; 95%-CI = 95%-credibility interval; regression coefficients whose credibility intervals do not include 0 are highlighted in bold.

^a Since ordinal models have multiple intercepts we do not reported them for brevity.

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Table 3

Latent Outcome Variability Compared Across Groups and Time

	Daily measurement				Pre-post measurement			
	First Day		Last Day		Pre-Test		Post-Test	
	σ	95%-CI	σ	95%-CI	σ	95%-CI	σ	95%-CI
<u>Well-being</u>								
Control Group ^a	1	-	0.86	[0.74, 0.98]	1	-	1.05	[0.88, 1.23]
ET Group	1.05	[0.94, .1.18]	0.86	[0.76, 0.96]	0.99	[0.82, 1.16]	0.97	[0.82, 1.15]
ENT Group	0.99	[0.89, .1.11]	0.84	[0.75, 0.95]	1.05	[0.88, 1.23]	0.99	[0.82, 1.18]
<u>Body Listening</u>								
Control Group ^a	1	-	0.92	[0.79, 1.06]			0.97	[0.77, 1.21]
ET Group	1.12	[0.99, .1.26]	0.85	[0.76, 0.95]	0.87	[0.70, 1.08]	1.04	[0.83, 1.28]
ENT Group	1.10	[0.98, .1.23]	0.88	[0.78, 0.99]	1.12	[0.91, 1.36]	1.08	[0.87, 1.33]
<u>Body Trusting</u>								
Control Group ^a	1	-	0.89	[0.76, 1.03]	1	-	1.03	[0.79, 1.33]
ET Group	1.02	[0.91, 1.14]	0.81	[0.72, 0.91]	1.28	[1.01, 1.59]	1.31	[1.03, 1.65]
ENT Group	1.03	[0.91, 1.15]	0.75	[0.67, 0.85]	1.10	[0.86, 1.37]	0.96	[0.76, 1.26]

Note. σ : latent standard deviation obtained from ordinal models varying across time and groups; 95%-CI: 95%-credibility interval of σ ; standard deviations whose credibility intervals do not include 1 are highlighted in bold.

^a The residual standard deviation of the control group measured in the pre-test is fixed to 1 for reasons of identifiability.

Table 4

Inclusion Criteria

The participants:

- (a) are between 18 and 40 years old, representing the main age group using fitness apps (Statista, 2017)
 - (b) self-report exercise behaviour of less than four hours per week on average to focus on participants who are not engaging in professional sport
 - (c) have not used a fitness app for longer than two weeks within the past six 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 under a state which can potentially influence the capability to exercise
 - (f) are not planning to travel for more than one week during the study period
 - (g) are not engaging in an employment requiring night shifts on a regular basis to ensure valid daily measurement and analysis of the data
-