



Activity Trackers @ Work

An Evaluation of a Cognitive-Behavioral mHealth Intervention in the Workplace

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M. Sc. Thomas Lennefer

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Präsidentin der Humboldt-Universität zu Berlin: Prof. Dr. Sabine Kunst

Dekan der Lebenswissenschaftlichen Fakultät: Prof. Dr. Bernhard Grimm

Gutachter/in

1. Prof. Dr. Annetkatrin Hoppe, Humboldt Universität zu Berlin
2. Prof. Dr. Dirk Lehr, Leuphana Universität Lüneburg
3. Prof. Dr. Lena Fleig, Medical School Berlin

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Zusammenfassung

Heutzutage erfüllen nur 35 % der Deutschen das empfohlene Maß an körperlicher Bewegung (Robert Koch Institute, 2015). Ein möglicher Grund für diese Inaktivität ist, dass die körperliche Betätigung am Arbeitsplatz sich in den letzten Jahren um insgesamt 28% verringert hat (Wilke, Ashton, Elis, Biallas, & Froböse, 2015). Um dieser Entwicklung entgegenzuwirken, evaluiert die vorliegende Dissertation eine mHealth Intervention bestehend aus Fitnessarmbändern und einem Online Coach, welche die Bewegung von inaktiven Beschäftigten mit Gesundheitsrisiko fördern soll. Obwohl Fitnessarmbänder in den letzten Jahren zunehmend an Popularität gewannen (Borrelli & Ritterband, 2015), fand diese Technologie bisher wenig Beachtung in der betrieblichen Gesundheitsförderung. Das zweite Kapitel zeigt daher, welche Elemente bereits in betrieblichen Interventionen zum Einsatz gekommen sind und wie die vorliegende Dissertation zu dieser Forschung beitragen kann. Kapitel 3 etabliert ein neues theoretisches Modell, welches als Rahmen für die betriebliche Gesundheitsverhaltensänderung diene. Kapitel 4 fasst die beiden Studien der Dissertation zusammen. Studie I bewertet den Effekt der Intervention auf körperliche Gesundheit und arbeitsbezogenem Wohlbefinden anhand eines randomisiert kontrollierten Studiendesigns und unter Berücksichtigung von Langzeiteffekten. Beschäftigte in der Interventionsgruppe zeigten eine Verbesserung ihrer physischen Gesundheit bis zu einem Jahr nach der Intervention, jedoch wurde kein Effekt auf arbeitsbezogenes Wohlbefinden gefunden. Studie II zeigt, dass die Schrittzahl und die Beeinträchtigung des Wohlbefindens während der Intervention verbessert werden und beantwortet weiterführende Fragen über die Effektivität der Intervention durch den Einsatz von modernen statistischen Methoden. Das fünfte Kapitel diskutiert die Ergebnisse der beiden Studien und überprüft basierend darauf die Struktur des neu kreierten Modells. Insgesamt zeigt die vorliegende Dissertation, dass Fitnessarmbändern kombiniert mit einem Online Coach eine effektive Intervention darstellen, um körperliche Aktivität, physische Gesundheit und das Wohlbefinden von Beschäftigten zu fördern.

Abstract

Nowadays only 35% of the German population performs the recommended amount of physical activity (Robert Koch Institute, 2015). A reason for this inactivity might be that the amount of moderate to vigorous physical activities at work (e.g., brisk walking or moving heavy loads) has diminished by about 28% within the last decades (Wilke et al., 2015). To counteract this alarming development, this dissertation evaluates an mHealth intervention that aims to promote physical activity in the working environment. In particular, this intervention combines activity trackers with an online coach to promote physical activity among inactive employees at risk. Even though activity trackers have become increasingly prominent within recent years (Borrelli & Ritterband, 2015), they have rarely been included in workplace health interventions. Thus, Chapter 2 gives an overview of the most widely used strategies for promoting physical activity and of how this dissertation contributes to this literature by examining the use of activity trackers in a workplace intervention. Chapter 3 describes a newly created model which was used as a theoretical framework for changing health behavior within a work setting. Chapter 4 summarizes the two studies of this dissertation. Study 1 evaluated the intervention by using a randomized controlled trial design and assessed long-term effects on employees' physical health and work-related well-being. The results show that employees in the intervention condition improved their physical health up to one year after the intervention whereas no effect was found for work-related well-being. Study 2 shows that the number of steps and impaired well-being were improved during the intervention and clarified several additional questions about the intervention's efficacy by applying modern statistical methods. Finally, Chapter 5 discusses the findings of the studies and reviews the theoretical structure of the newly created model based on both studies' results. Taken together, the overall findings show that combining activity trackers with an online coach constitutes an effective intervention for occupational health promotion with the aim of promoting physical activity, health and well-being among employees.

Chapter 1

Introduction

Within the last years the workplace has changed significantly due to the increasing use of machines and technology that replace large parts of physical activity at work. As a result, the work environment becomes increasingly sedentary (e.g., sitting working at computers) (Brownson, Boehmer, & Luke, 2005; Church et al., 2011; Wilke et al., 2015). As an example, an office worker nowadays spends up to 71% of his or her time at work doing sedentary activities, so that approximately half of the overall daily sitting time is work-related (Clemes, O'Connell, & Edwardson, 2014; Kazi, Duncan, Clemes, & Haslam, 2014; Miller & Brown, 2004).

This development is highly alarming since physical activity, which is defined as any bodily movement produced by skeletal muscles resulting in energy expenditure, prevents the incidence of several serious diseases (Caspersen, Powell, & Christenson, 1985; Czosnek et al., 2019; Rhodes, Janssen, Bredin, Warburton, & Bauman, 2017). To obtain these health benefits, various physical activity guidelines recommend that an adult should perform at least 150 minutes of moderate to vigorous physical activity per week (Department of Health and Social Care, 2019; U.S. Department of Health and Human Services, 2018; World Health Organization, 2010). This recommendation could already be accomplished by cycling to and from work for 15 minutes each way on five days a week. However, only 35-44% of the German adult population meets these recommendations (Robert Koch Institute, 2015). At the same time fulfilling or exceeding the physical activity guidelines reduces the risk of mortality and several chronic diseases by 20-30% (e.g., diabetes or cardiovascular diseases; Warburton & Bredin, 2016; Warburton, Charlesworth, Ivey, Nettlefold, & Bredin, 2010). Further research has even shown that the decrease in physical activity at work is responsible for a significant portion of society's increase in obesity, which not only harms the individual but also raises the employer's health care costs (Church et al., 2011; van Nuys et al., 2014). Due to these results and the expectation that digitalization and the increasing use of technology might further reduce physical activity at work (Hendriksen, Bernaards, Steijn, & Hildebrandt,

2016), physical inactivity is regarded to be one of the biggest public health problems of the 21st century (Blair, 2009). Thus, effective interventions are needed to promote physical activity among employees.

Addressing this need this dissertation aims to evaluate the effect of a cognitive-behavioral mHealth intervention on employees' physical activity, health, and well-being. The behavioral approach of the intervention involved implementing activity trackers, which are small electronic devices that can be worn on a user's body to collect and display health data such as the number of steps (Evenson, Goto, & Furberg, 2015; Hoy, 2016; Ilhan & Henkel, 2014). To further raise awareness and motivation to change health behavior, an online coach was used as a cognitive approach, offering advice on health behavior change (e.g., how to set health behavior goals). In the next Chapter, the literature on workplace health interventions will be reviewed along with a description of the dissertation's contribution to this literature regarding aspects such as the study design, its sample, and the intervention strategies.

Chapter 2

Intervention Strategies for Increasing Physical Activity

2.1. Workplace Interventions for Increasing Physical Activity

Given that individuals spend over a third of their waking time at work (To, Chen, Magnussen, & To, 2013), it becomes apparent that the workplace is an important and ideal setting for the promotion of health and prevention of diseases. Thus, in the past, various physical activity interventions have been implemented in the workplace. To evaluate the effectiveness of physical activity workplace interventions, Taylor, Conner, and Lawton (2012) conducted a meta-analysis considering 26 studies. The results revealed that such interventions increased employees' physical activity with an average small effect size ($d = .21$). Further studies have supported the effectiveness of workplace interventions in increasing physical activity (e.g., Commissaris et al., 2016; Malik, Blake, & Suggs, 2014). Despite the availability of studies, many researchers have pointed out that there is still a lack of high-quality randomized controlled intervention studies with employees (Malik et al., 2014; Rongen, Robroek, van Lenthe, & Burdorf, 2013) as well as a lack of studies capturing long-term effects that exceed several weeks (Hutchinson & Wilson, 2012; Lock, Post, Dollman, & Parfitt, 2020). To address this lack of research, this dissertation uses a randomized controlled trial design (RCT) to draw causal conclusions about the intervention's efficacy. Additionally, to capture long-term effects, the intervention's effects will be assessed one month, three months, and one year after the intervention.

One aspect which still remains challenging for workplace physical activity interventions is motivating less healthy employees to change their health behavior (Muir et al., 2019). In a recent review, Muir et al. (2019) showed that healthier employees more intensely engaged in intervention strategies and experienced a more successful health behavior change compared to their less healthy colleagues. A reason why workplace health interventions are seemingly more beneficial for healthier employees might be the design of these interventions. Muir et al. (2019) revealed that most of the interventions were one-size-fits-all programs which do not accommodate possible individual differences in employees' motivation. To address this issue,

this dissertation uses activity trackers as an intervention strategy, since these devices can adapt their content towards the needs and motivation of their users. However, especially inactive employees at risk for adverse health outcomes need to be supported by workplace health interventions. Thus, the sample of this dissertation was recruited at a large company that offered access to this special kind of population which had rarely been targeted in workplace intervention research.

With regard to the content of workplace health interventions, most studies have either focused on a cognitive approach (e.g., advice on physical activity, Spittaels, Bourdeaudhuij, Brug, & Vandelanotte, 2007) or a behavioral approach (e.g., treadmill desk interventions, Schuna et al., 2014) to promote physical activity. Combining both approaches might potentially result in an even higher increase in physical activity. As Hutchinson and Wilson (2012) showed in their meta-analysis, there is promising evidence from one study which implemented a cognitive-behavioral intervention promoting physical activity in the workplace and yielded a large effect size ($d = .90$). Besides the combination of cognitive and behavioral approaches, previous research has shown that workplace interventions which applied internet-based approaches were more likely to be effective since employees were able to decide when they wanted to engage in the intervention activities (To et al., 2013). Thus, a cognitive-behavioral intervention using an internet-based approach might be especially effective for promoting physical activity in the workplace. Drawing on this idea, this dissertation aims to evaluate an intervention combining activity trackers as a behavioral approach with an online coach as a cognitive approach.

2.2. eHealth and mHealth Interventions for Increasing Physical Activity

Technological progress in the 21st century has given rise to unprecedented possibilities for promoting healthcare and has greatly facilitated access to healthcare measures (Bhavnani, Narula, & Sengupta, 2016; Borrelli & Ritterband, 2015). In this context, the term electronic

health (eHealth) is an umbrella term which refers to the implementation of electronic devices within the healthcare system (e.g., using computers instead of paper files for the documentation of patient records; Aanestad, Grisot, Hanseth, & Vassilakopoulou, 2017; Borrelli & Ritterband, 2015). A specific form of eHealth is mobile health (mHealth) which describes the usage of mobile technology to provide healthcare (Borrelli & Ritterband, 2015; World Health Organization, 2011). Thus, mHealth interventions include technology such as smartphones or wearable devices to improve a certain health behavior. These interventions offer several advantages over traditional intervention strategies (e.g. personal fitness trainers) for promoting physical activity. The mobility aspects of mHealth interventions allow an on-demand service, which means that they are usable irrespective of the location and time. As such, mHealth interventions have the potential to be integrated into the everyday work life of employees with different working conditions (Borrelli & Ritterband, 2015; Lehr et al., 2016). Additionally, most mHealth interventions are highly tailorable so that they can even adjust their content if the user's need changes (Patrick, Griswold, Raab, & Intille, 2008; Riley et al., 2011). From an economic perspective, previous research has shown that mHealth interventions are cost-effective and economically beneficial which makes them an interesting approach for promoting health behavior change (Iribarren, Cato, Falzon, & Stone, 2017).

To better understand these advantages, Cotie et al. (2018) conducted a meta-analysis on the effectiveness of technology-based interventions on physical activity. The results showed that the interventions effectively improved physical activity by increasing participants' moderate to vigorous physical activity by 25 minutes per week on average. Further studies have confirmed the positive effect of mHealth interventions on physical activity in different samples (Bort-Roig, Gilson, Puig-Ribera, Contreras, & Trost, 2014; Davies, Spence, Vandelanotte, Caperchione, & Mummery, 2012; Müller, Alley, Schoeppe, & Vandelanotte, 2016; van Drongelen et al., 2014). Nevertheless, in a systematic review, Buckingham, Williams, Morrissey, Price, and Harrison (2019) postulated that the methodological quality of

mHealth physical activity interventions conducted at work is rather weak since most studies, inter alia, do not include a true control group. Additionally, technology-based intervention studies mostly fail to consider long-term effects and to incorporate objective measures (Bort-Roig et al., 2014; Buckingham et al., 2019; Laplante & Peng, 2011). Thus, there is a high need for sound studies investigating the effect of recent mHealth technologies in the workplace. This dissertation aims to meet this need by applying a strong research design with overall eleven points of measurement and data analysis using modern statistical methods (e.g., latent growth curve modelling). Hence, this dissertation will contribute to the research by determining the long-term effects of a workplace intervention and understanding further important questions such as if the change in physical activity is related to the change in employees' well-being.

An mHealth technology which provide a convenient way to objectively assess physical activity with high validity are activity trackers (Huang, Xu, Yu, & Shull, 2016; Simunek et al., 2016). Today, 24% of the German population uses an activity tracker and the market is predicted to continue growing (Gentemann, 2016; Wade, 2017). Although this technology combines several features which have been shown to be effective in increasing physical activity, activity trackers have rarely been included in workplace interventions. Indeed, a recent meta-analysis showed that setting behavioral goals and self-monitoring are important elements which contribute to the success of mHealth physical activity interventions (Eckerstorfer et al., 2018). Furthermore, Bardus, Blake, Lloyd, and Suggs (2014) investigated the reasons why employees participate in technology-based interventions aiming to improve physical activity. The results revealed that elements such as addressing individual needs and providing regular reminders encouraged employees to participate. As activity trackers combine these elements, this mHealth technology might be particularly effective in increasing employees' physical activity which will be examined in this dissertation.

Chapter 3

Introducing the Occupational
Health Behavior Change
Model

So far a wide range of models have been based on assumptions on how to change and promote health behavior and applied different foci. In industrial and organizational psychology (I/O), theoretical models have especially focused on work characteristics that influence employees' health behavior (e.g., physical activity). Furthermore, some models reported in the I/O literature are grounded on assumptions that health behavior change is associated with health improvement. One model, that integrates both aspects, is the Physical Activity-Mediated Demand-Control model (pamDC model) which was recently introduced by Häusser and Mojzisch (2017). The pamDC is based on the well-established Job Demand-Control model by Karasek (1979) and on the premise that job control can positively influence employees' physical activity, which in turn improves health outcomes (see Figure 1; Häusser & Mojzisch, 2017).

In contrast to the work focus of the I/O models (e.g., pamDC), theoretical models reported in the health psychology literature rather concentrate on the internal processes that are relevant for initiating health behavior change. Hence, theoretical models such as the Health Action Process Approach (HAPA) model consider factors that explain why some people change their health behavior (e.g., become physically active) whereas others do not succeed in changing their health behavior (Schwarzer, 2008). Addressing this disparity, the HAPA model divides health behavior change into a motivational phase leading to a behavioral intention and a volitional phase leading to the actual health behavior (see Figure 2; Schwarzer, 2008).



Figure 1. Simplified version of the pamDC model.

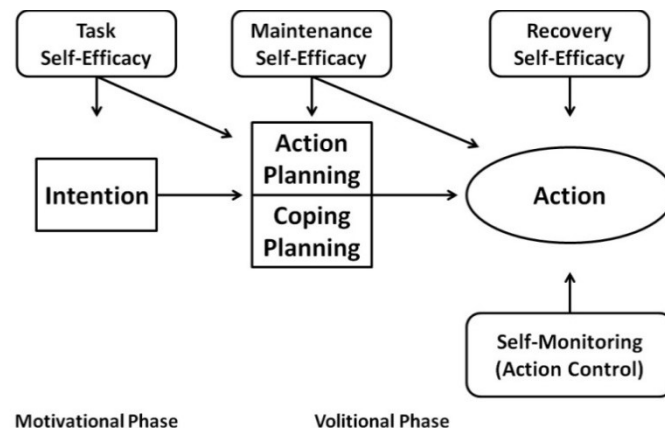


Figure 2. Simplified version of the HAPA model.

Both models (i.e., pamDC and HAPA) have their justification and are based on theoretical assumptions that are well established within their fields (Hattar, Pal, & Hagger, 2016; Häusser, Mojzisch, Niesel, & Schulz-Hardt, 2010; Lange, Taris, Kompier, Houtman, & Bongers, 2003; Parschau et al., 2014; Scholz, Keller, & Perren, 2009; Zhang, Zhang, Schwarzer, & Hagger, 2019). However, to change health behavior among employees, it might be especially beneficial to integrate the different foci of the two disciplines within one theoretical model. To this end, this dissertation proposes the Occupational Health Behavior Change (OHBC) model which is inspired by the pamDC model and the HAPA model (see Figure 3). The OHBC model will be presented in the following paragraphs in detail together with an explanation of how it functions as a framework for this dissertation.

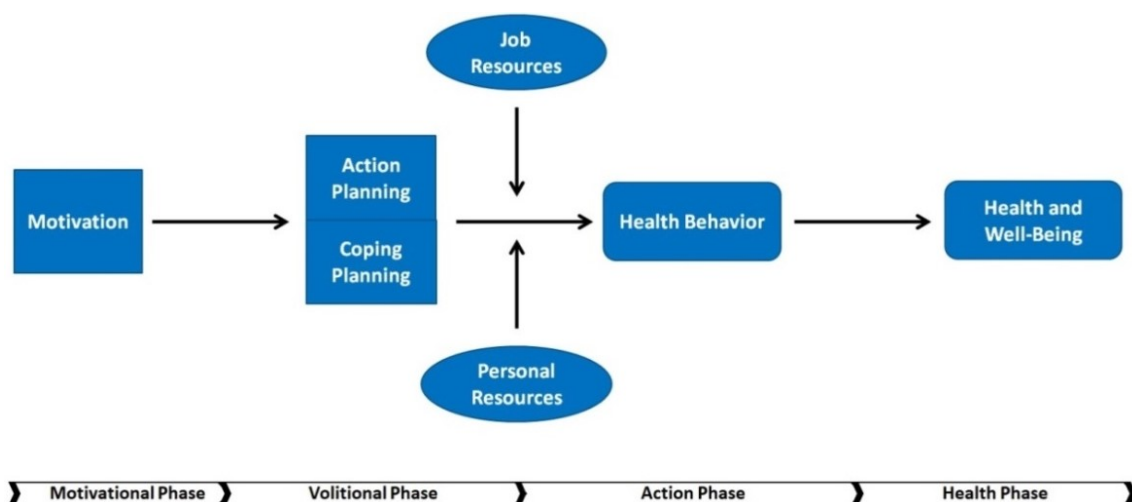


Figure 3. Illustration of the OHBC model.

3.1. The Motivational Phase: Forming Intentions for Health Behavior Change

An essential prerequisite for health behavior change is that employees are motivated to change their behavior (e.g., increase their physical activity). As previous research showed, worksite interventions that incorporate approaches for enhancing motivation are especially successful in leading employees towards health behavior change (Hutchinson & Wilson, 2012). Thus, the first phase of the OHBC model is the motivational phase, in which employees become motivated to change their health behavior, resulting in an intention to change their health behavior (e.g., “I want to become physically active”).

The concept of motivation can be divided into extrinsic and intrinsic motivation (Deci, 1985; Deci, Olafsen, & Ryan, 2017; Deci & Ryan, 2008). Extrinsic motivation involves a certain behavior being performed in expectation of an external reward or benefit (e.g., money; Deci, 1985). In contrast, intrinsic motivation describes the motivation to perform a certain behavior due to a natural interest and pleasure in an activity (e.g., enjoyment during physical exercise; Deci, 1985). According to the self-determination theory (SD-Theory) by Ryan and Deci (2002), intrinsic motivation is the most desirable form of motivation, because it is more sustainable than extrinsic motivation as it is not dependent on external factors. This assumption has also found empirical support; it has been shown that intrinsic motivation is especially relevant for maintaining changed health behavior such as staying physically active (Ryan, Frederick, Lepes, Rubio, & Sheldon, 1997; Teixeira, Carraça, Markland, Silva, & Ryan, 2012).

According to the SD-Theory, intrinsic motivation is based on the satisfaction of three basic psychological needs: *competence*, *autonomy*, and *relatedness*. *Competence* describes the desire to be effective in one's ongoing interactions and express one's own capacities by overcoming challenges and building skills. *Autonomy* refers to an individual's feeling of being the origin of his or her own behavior. Finally, *relatedness* describes the need to be connected to others and to have a sense of belonging to other individuals or communities (Ryan & Deci,

2002). The stronger these three psychological needs are fulfilled, the more an individual is intrinsically motivated to perform and maintain a certain behavior (e.g., physical activity; Gunnell, Crocker, Mack, Wilson, & Zumbo, 2014; Silva et al., 2010).

Activity trackers and their associated apps show a high potential for addressing these three psychological needs, which is why me and my colleagues used this approach to motivate employees to become physically active. To fulfill the user's need for *competence*, the activity trackers used in the intervention offer the feature of automatically setting an individual activity goal related to the current activity level of the user. Thus, the automatic activity goal is customized by considering the user's current step count and is adjusted if he or she walks more or less steps than before. Based on this technique, activity trackers might enhance a user's feeling of *competence*, since the set goal could be regarded as a challenge which never exceeds the current skill level of the user. Additionally, the activity tracker alerts the user if the activity goal is reached and awards badges when further activity goals are accomplished (e.g., reaching the daily step goal every day of the week).

The *need for autonomy* could be satisfied by enabling users to customize information about their health behavior displayed on the associated app depending on their individual needs. Additionally, besides the activity goal which is automatically proposed by the activity tracker, it is also possible to modify the activity goal. Thus, the user is able to define an activity goal according to his or her personal activity needs. In addition, activity trackers do not prescribe the type of activity the user should perform to reach the goal (e.g., walking, cycling, and swimming). This aspect could further increase the user's feeling of *autonomy*.

Activity trackers are connected to different social networks and very often offer a large and active community, which addresses the user's *need for relatedness*. Hence, the activity tracker used in this dissertation provides the option of sharing reached activity goals on social networks such as Facebook. Moreover, it is possible to challenge peers or other users to engage in physical activity competitions, so that the user's feeling of being connected to a

social environment is satisfied. Thus, it can be assumed that the activity tracker increases employees' intrinsic motivation to become more physically active. Besides the activity tracker, me and my colleagues introduced a step challenge as a gamification element. The step challenge aims to additionally increase employees' intrinsic motivation by promoting their enjoyment of being physically active and activating extrinsic motivation by offering a reward. During the challenge, employees were required to walk more than 40 000 steps in total within four days. If at least 50% of the participants reached this goal, a reward was given to the participants for winning the challenge.

3.2. The Volitional Phase: Turning Intentions into Actions

As pointed out previously, motivation is an essential factor for health behavior change. Nevertheless, various studies have shown that only being motivated to change one's health behavior does not inevitably result in an actual change of behavior (Sheeran, 2002). For instance, a meta-analysis showed that 46% of the participants who intended to engage in physical activity were not able to act on their intention (Rhodes & Bruijn, 2013). The discrepancy between intention and actual behavior is called the intention-behavior gap (Sheeran, 2002).

Planning has been shown to be an effective strategy to overcome the intention-behavior gap (Fleig et al., 2013; Sniehotta, Scholz, & Schwarzer, 2005). Hence, two forms of planning constitute the volitional phase of the OHBC model: *action planning* and *coping planning*. *Action planning* refers to a detailed definition of when, where, and how a desired behavior will be carried out. Thus, this form of planning is more than an extension of the intention, since it creates a mental representation of a suitable situation and the behavioral action (Schwarzer, 2008; Sniehotta, Scholz et al., 2005). Moreover, *action planning* is regarded as an effective strategy for transferring intentions into behavior, since employees remember their

intentions more easily and the predetermined situational cues (i.e., when and where) can elicit the desired health behavior almost “automatically” (Schwarzer, 2008).

The second form of planning is *coping planning* which involves specifying the internal and external barriers that prevent employees from showing the desired health behavior (Sniehotta, Schwarzer, Scholz, & Schüz, 2005; Wiedemann, Lippke, Reuter, Ziegelmann, & Schüz, 2011). By identifying barriers, employees link anticipated risk situations to a suitable coping response (e.g., changing the location in which they planned to carry out the desired health behavior), which helps them to act according to their intentions (Sniehotta, Schwarzer et al., 2005). Thus, an example of a coping plan could be: “If it is raining and I was planning to go out for a run, I will go to the gym instead.” As this example already implies, *coping planning* is an advanced strategy, which comes on top of *action planning* and should additionally support employees to act on their intentions (Schwarzer, 2008). Nevertheless, studies have shown that both forms of planning are effective in improving health behaviors such as physical activity (Fleig, Ashe, Keller, Lippke, & Schwarzer, 2019; Luszczynska, 2006; Wiedemann et al., 2011; Williams & French, 2011; Ziegelmann, Lippke, & Schwarzer, 2006).

In the mHealth intervention set out in this dissertation, *action planning* and *coping planning* were introduced to employees by an online coach. The online coach was a website from which participants could retrieve pieces of advice on how to increase their physical activity twice a week (Mondays and Fridays) during the three intervention weeks. As a first piece of advice, employees were introduced to *action planning* in the form of a tool for goal setting. The tool first required employees to define their individual health behavior goal. In a second step, we asked them to generate a plan on how they could achieve their individual goal. Further pieces of advice supported employees to reach their individual health behavior goal. Thus, the online coach also explained how to generate *coping plans*, so that barriers could be overcome and employees could even become physically active in individual risk

situations. Overall, both forms of planning aimed to help employees to bridge the intention-behavior gap and turn their intentions into actions.

3.3. The Action Phase: Resources Encouraging Health Behavior

The third phase of the OHBC model is the action phase, in which the actual health behavior change is accomplished by performing the desired health behavior. To evaluate health behavior change, it is advisable to apply subjective and objective measures. Subjective measures capture employees' perceptions of their health behaviors, whereas objective measures generate data about the actual performed health behaviors. With regard to physical activity, studies have shown that both forms of measurement are associated with health improvement (Füzéki, Engeroff, & Banzer, 2017; LaMonte et al., 2017; Puig-Ribera et al., 2015; Rödjér et al., 2012). Nevertheless, one study showed that subjective physical activity is associated with mental health whereas no association was found between objectively measured physical fitness and mental health (Lindwall, Ljung, Hadžibajramović, & Jonsdottir, 2012). In contrast, studies have shown that objectively measured physical activity is more strongly related to objective health indicators (e.g., Body mass index and insulin concentration; Atienza et al., 2011; Celis-Morales et al., 2012). A reason for this disparity could be that subjective and objective measures capture different aspects of physical activity (feeling active vs. being active) which might be differently associated with health indicators (Atienza et al., 2011). Thus, it is reasonable to consider both forms of measurement to assess occupational health behavior change. Nevertheless, previous studies have revealed a lack of studies using objectives measures (Laplane & Peng, 2011), which is why this dissertation used objective measures (i.e., number of steps registered by the activity tracker) and subjective measures (i.e., the Godin Leisure-Time Exercise Questionnaires; Godin & Shephard, 1985) to evaluate the effectiveness of the intervention on employees' physical activity.

Besides the performance of the desired health behavior, the action phase of the OHBC model also includes work-related and personal resources which could further facilitate employees' health behavior change (e.g., becoming physically active). Within the OHBC model, resources are regarded as external (i.e., job resources) or internal factors (i.e., personal resources) which facilitate employees to act on their intentions and therefore support health behavior change. Unquestionably, some work-related and personal factors also have a negative impact on health behavior change (e.g., time pressure; Welch, McNaughton, Hunter, Hume, & Crawford, 2009). Due to the resource-oriented nature of the model, I will only concentrate on and describe supporting factors in the following section.

As a job resource, job control seems to be an important factor which supports an increase of employees' physical activity (Häusser & Mojzisch, 2017). Job control refers to the extent to which employees are able to influence their working conditions, such as the pace of work or the order in which tasks are fulfilled (Semmer, Zapf, & Dunckel, 1995). Thus, it is possible that a high degree of job control makes it easier for employees to integrate intervention strategies that promote physical activity into their daily work routines. This assumption has been supported by several studies which show that job control is positively associated with physical activity (Choi et al., 2010; Cifuentes, Qin, Fulmer, & Bello, 2015; Fransson et al., 2012; Griep et al., 2015; Kouvonen et al., 2005).

With regard to personal factors, self-efficacy could be a resource which helps employees to act on their intentions and become physically active. Generally, self-efficacy refers to the sense of control over one's environment and behavior (Schwarzer & Luszczynska, 2007). Thus, employees who have high self-efficacy regarding physical activity might be more likely to carry out a health behavior change, since they believe that they are capable of increasing their physical activity. Furthermore, self-efficacy influences the persistence and effort put into changing a behavior (Schwarzer & Luszczynska, 2007). For these reasons, employees with high self-efficacy might engage more intensely in the intervention's activities which could

result in a stronger increase in physical activity. This assumption is supported by previous studies which show that self-efficacy can support an increase in physical activity (Bauman et al., 2012; Pedersen et al., 2013; Prodaniuk, Plotnikoff, Spence, & Wilson, 2004; Stutts, 2002; Williams & French, 2011). Hence, the mentioned work-related and personal resources could help employees to succeed in changing their health behavior, which in turn could benefit their health.

3.4. The Health Phase: Health Benefits from Changing Health Behavior

The last phase of the OHBC model is the health phase, in which the accomplished health behavior change should bear fruit by improving the employee's health status. Several health behaviors positively influence different health outcomes (Chastin et al., 2019; Leitzmann et al., 2007; Li & Siegrist, 2012; Rebar et al., 2015), so that different health and well-being outcomes should be taken into consideration to evaluate health effects. For this purpose, it is advisable to consider subjective and objective measurements. Besides the importance of having realistic objective data, self-reported data offer a different aspect of employees' health and well-being. For instance, health perception, which is defined as an individual's perception of his or her own health status (Benyamini, 2012), integrates several relevant health factors such as physiological factors, symptom status, and functioning (Havranek et al., 2001; Wilson & Cleary, 1995). The integration of these factors makes health perception function as a strong and effective predictor of mortality (Burstrom, 2001; DeSalvo, Bloser, Reynolds, He, & Muntner, 2006). As shown with the example of health perception, subjective measures also provide important information regarding employees' health and well-being.

Besides the inclusion of subjective and objective measures, time is also an important aspect which should be taken into consideration when evaluating the effects of health behavior change. It might be possible that some indicators of health and well-being are more directly affected by health behavior change than others. For instance, physical activity triggers

different biological processes such as the inhibition of parts of the brain that are responsible for emotions (Dietrich, 2006; Dietrich & Sparling, 2004; Ide & Secher, 2000). Hence, it is possible that physical activity has a more direct impact on mood indicators (e.g., negative affect), which might already be found in the short-term (Berger & Motl, 2000; Yeung, 1996). With regard to more severe health and well-being outcomes (e.g., burnout), it is possible that indicators of such conditions might only be affected in the long run, since more physical activity is needed to reveal a positive effect. However, due to the paucity of research on the longitudinal effects of physical activity interventions (Blake, Mo, Malik, & Thomas, 2009; Hutchinson & Wilson, 2012; Malik et al., 2014; Reiner, Niermann, Jekauc, & Woll, 2013), the positive effect on more severe indicators might not be fully explained yet. As a consequence, it is beneficial to evaluate the effect of health behavior change on employees' health and well-being in the short-term and long-term by considering light, severe, subjective, and objective measurements of health and well-being.

Given these recommendations, this dissertation considers the long-term effects and examines the development of different *health* and *well-being* indicators during the intervention (see Table 1). Regarding *health*, body mass index (BMI) was chosen as an objective indicator, and health perception was taken as a global subjective indicator, because it integrates physiological factors, symptom status, and functioning (Havranek et al., 2001; Wilson & Cleary, 1995). Previous studies have shown that both indicators of health could be improved by physical activity interventions conducted at work (e.g., Anderson et al., 2009; Pohjonen & Ranta, 2001; Reed et al., 2017).

In relation to *well-being*, this dissertation considers four different outcomes (i.e., burnout, emotional strain, vigor, and negative affect) which differ regarding their severity and their relation to the occupational context. As a more severe indicator of well-being, burnout, which even shares some characteristics with the mental disorder depression, was selected (Koutsimani, Montgomery, & Georganta, 2019). Additionally, emotional strain, as a less

Table 1

Overview of the Health and Well-Being Indicators Considered in this Dissertation

Construct	Definition	Objectivity		Severity		Context relation	
		Objective	Subjective	Severe	Less severe	Work-related	Context-free
Body mass index	A traditional index which sets body weight in relation to height (kg/m ² or lbs/inch ² ; World Health Organization, 2000)	X		X			X
Health perception	An individual's perception of his/her own health status (Benyamini, 2012).		X	X			X
Burnout	An affective reaction occurring as a result of exposure to prolonged stress at work (Shirom, Melamed, Toker, Berliner, & Shapira, 2005).		X	X		X	
Emotional strain	An emotionally irritable reaction causing negative interactions between the social environment and the emotionally strained employee (Mohr, Rigotti et al., 2005).		X		X	X	
Vigor	Feeling of high levels of energy and mental resilience at work (Schaufeli, Bakker, & Salanova, 2006)		X		X	X	
Negative affect	The extent to which a person generally feels various aversive mood states (e.g., anger and nervousness; Watson, Clark, & Tellegen, 1988).		X		X		X

severe stress indicator which is focusing solely on the emotional aspect of occupational stress, was chosen (Mohr, Rigotti, & Müller, 2005). Although these constructs differ regarding their severity, previous studies have shown that both constructs are associated with employees' physical activity (e.g., Conn, Hafdahl, Cooper, Brown, & Lusk, 2009; Hansen, Blangsted, Hansen, Sjøgaard, & Sjøgaard, 2010; Tsai et al., 2013; van Rhenen, Blonk, van der Klink, van Dijk, & Schaufeli, 2005). Besides the stress indicators, vigor and negative affect were included as a work-related and general indicator. Even though vigor and negative affect comprise different aspects of well-being, most studies have shown promising results regarding their relation to physical activity (Abrantes et al., 2017; Bruin, Formsma, Frijstein, & Bögels, 2017; ten Brummelhuis & Bakker, 2012; Hansen et al., 2010; Pronk, Katz, Lowry, & Payfer, 2012). In summary, this dissertation considers several measures which capture different aspects of health and well-being to comprehensively evaluate the effect of an intervention with activity trackers on employees' health and well-being. Figure 4 illustrates how the different phases of the OHBC model were operationalized within this dissertation.

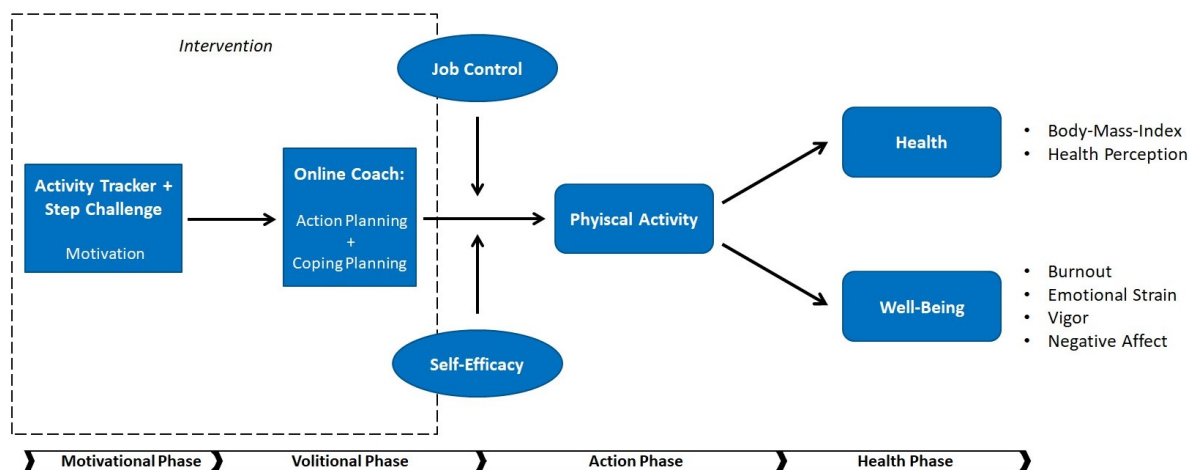


Figure 4. Illustration of the operationalization of the OHBC model.

Chapter 4

The present Dissertation

The empirical part of this dissertation composes two published studies that examined the effect of a cognitive-behavioral mHealth intervention aiming to increase employee's physical activity. The next paragraph will explain how these studies tested the structure of the OHBC model. As described in Chapters 3.1 and 3.2, the motivational and volitional phases of the OHBC model were operationalized by the intervention elements (see Figure 5). Study 1 tested whether these intervention elements were effective in increasing employees' physical activity (action phase, see Chapter 3.3) by using an RCT design. Additionally, it tested the impact of promoting physical activity on health (health phase, see Chapter 3.4) by considering the long-term effects on different indicators of physical health and work-related well-being. To further evaluate the concept of the OHBC model, Study 2 analyzed more detail how health and health behavior changed during the intervention. Thus, as described in the action phase, it tested the effect of job resources and personal resources on the change in employees' number of steps during the intervention. Additionally, the relationship between the change in number of steps and impaired well-being was examined to gain a more detailed understanding of the relation between the action phase and the health phase. The following section provides a summary of both studies; the full manuscripts can be found in the Appendix.

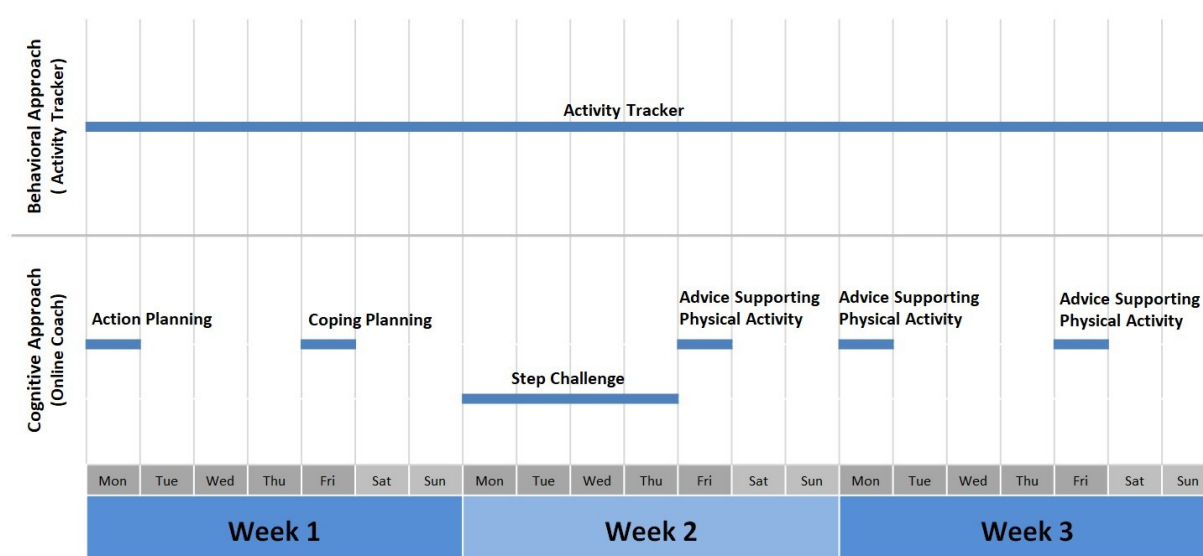


Figure 5. Overview of the intervention elements of both studies.

4.1. Summary Study 1¹

Publication Information Study 1	
Title:	Improving Employees' Work-Related Well-Being and Physical Health Through a Technology-Based Physical Activity Intervention: A Randomized Intervention-Control Group Study
Date of Publication	2020
Journal:	Journal of Occupational Health Psychology
5-Year Impact Factor:	5.854
Journal's Quality:	A (Australian Business Deans Council, 2019)

Research Aim and Study Design

The first study aimed to evaluate the effectiveness of an intervention with activity trackers on employees' work-related well-being (i.e., burnout and vigor) and physical health (i.e., health perception and BMI). Additionally, the effect of the mHealth intervention on employees' physical activity was tested as a manipulation check assessed by the Godin Leisure-Time Exercise Questionnaires (Godin & Shephard, 1985). To draw causal conclusions about the effectiveness of the intervention, an RCT design was used comparing employees who engaged into intervention's activities with employees who received no treatment. The data were assessed online at five points of measurement, with employees filling out a prequestionnaire (T1), a postquestionnaire (T2), and three follow-up questionnaires one month (T3), three months (T4), and one year (T5) after the intervention. To test for intervention effects and long-term effects, repeated analyses of variance (ANOVA) were applied to the data.

¹ To read the full manuscript of Study 1, please refer to the Appendix.

Sample

Study 1 considered employees at risk who were recruited from one large company in Germany. During recruitment employees' attention was drawn to a website where they could register for study participation. To be eligible, they had to be 18 years or older and were not medically required to be on a diet or follow an activity plan. Thus, 121 employees at risk were randomly assigned to an intervention group (IG) and a waitlist control group (CG) using simple randomization conducted by a computerized random number generator. Given that some participants did not complete the prequestionnaire (T1) the final sample consisted of 116 employees at risk (IG: $n = 59$; CG $n = 57$; see Figure 6). Within this sample, the employees' age ranged from 19 to 62 years ($M = 43.01$; $SD = 12.72$); 66.4% had completed a vocational training or lower secondary education, and 45.7% were female. Due to the focus on inactive employees at risk during recruitment, 68.1% of the employees in the final sample were classified as overweight or obese (BMI: $M = 27.21$, $SD = 4.74$).

Results

The results revealed that employees in the IG significantly increased their physical activity compared with those in the CG after the intervention. Thus, employees in the IG were 31.0% more physically active compared to their baseline physical activity ($M_{T1} = 18.98$, $M_{T2} = 24.86$). With regard to the health and well-being indicators, the analyses showed that employees perceived their health as being better than before the intervention until three months after the intervention. Furthermore, employees in the IG significantly reduced their BMI compared to the CG. The effect of the reduction of employees' BMI persisted until one year after the intervention, with employees decreasing their BMI up to 0.45 points on average. A reason why the mHealth intervention yielded sustained effects might be that 84.2% of the employees still used the activity trackers three months after the intervention and 74.3% of the employees still used the activity tracker one year after the intervention. However, in spite of

its positive effects on physical health, the mHealth intervention approach was not effective in improving work-related well-being (i.e., burnout and vigor).

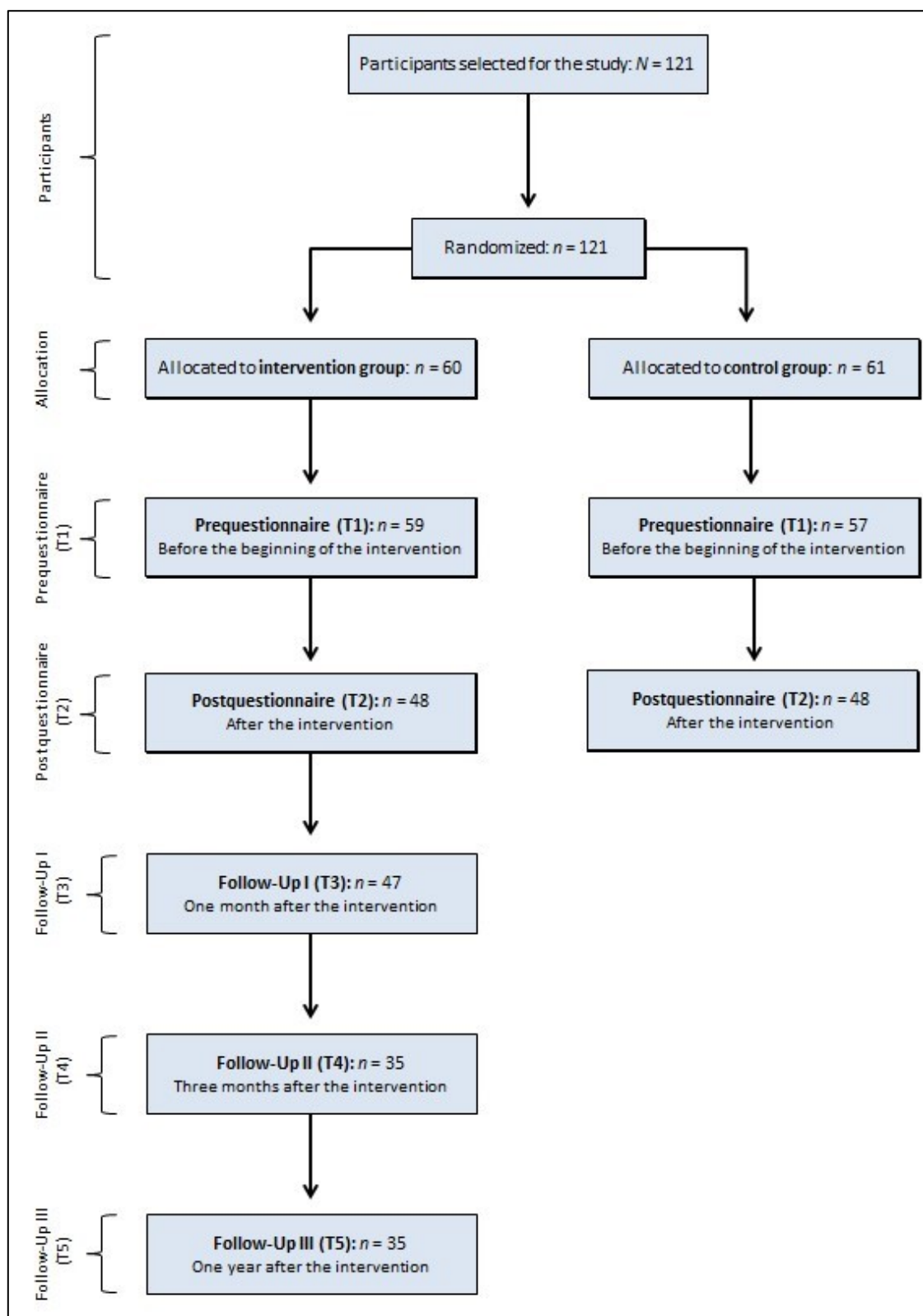


Figure 6. Consort diagram: Participation and allocation in Study 1.

4.2. Summary Study 2²

Publication Information Study 2	
Title:	A Step away from Impaired Well-being: A Latent Growth Curve Analysis of an Intervention with Activity Trackers among Employees
Date of Publication	2020
Journal:	European Journal of Work and Organizational Psychology
5-Year Impact Factor:	3.698
Journal's Quality:	A (Australian Business Deans Council, 2019)

Research Aim and Study Design

The aim of the second study was to analyze the development of physical activity and impaired well-being (i.e., emotional strain and negative affect) during an intervention with activity trackers. To assess physical activity as the primary outcome, objective data registered by the activity tracker (i.e., number of steps) were used. Over the course of the three intervention weeks, data were collected twice a week (Monday and Friday), resulting in six points of measurement (T1-T6). The data were analyzed using latent growth curve modelling (LGCM) and latent change score modelling (LCS) which provided answers to several questions in addition to the direct intervention effects on the number of steps, emotional strain, and negative affect. Thus, by applying LGCM, it could be examined whether the growth in number of steps was influenced by job control and self-efficacy, which were both measured before employees engaged in the intervention activities (T0). Additionally, the change in number of steps was related to the change in emotional strain and negative affect by using parallel process growth modelling. LCS allows, amongst other things, the determination of time point at which the mHealth intervention started to yield an effect regarding the three outcome measures.

² To read the full manuscript of Study 2, please refer to the Appendix.

Sample

Study 2 considered a sample of mainly inactive employees who were recruited from one large company in Germany. The sample size was based on the recommendations of Curran, Obeidat, and Losardo (2010) who stated that approximately 100 participants are sufficient for the application of LGCM. Given that some participants were expected to drop out during the study, a larger number of employees were recruited, resulting in a sample of 121 employees. Employees who filled out fewer than two questionnaires during the intervention (T1-T6) were excluded from the analyses; the final sample therefore consisted of 108 employees (see Figure 7). As recruitment focused explicitly on inactive employees, 62.0% of employees in the final sample did not reach the recommended number of 10,000 steps per day (Tudor-Locke et al., 2011). Additionally, 35.9% of the employees could even be classified as sedentary or low active (<7,499 steps per day; Tudor-Locke, Hatano, Pangrazi, & Kang, 2008).

Results

The LGCM analyses showed that the employees increased their number of steps over the course of the intervention. Thus, the employees walked 1,338 more steps per day on average compared to at the beginning of the intervention. Further analyses revealed that this increase was not moderated by job control or self-efficacy. With regard to improvement of impaired well-being, emotional strain was significantly reduced during the intervention. Even though the employees' emotional strain was already lower than the mean score of the norm sample ($M = 2.87$) at the beginning of the intervention (Mohr, Müller, & Rigotti, 2005), employees further decreased their emotional strain by an average of 0.3 points during the intervention. Additionally, employees' negative affect was significantly reduced by up to 0.25 points during the three intervention weeks. Since employees' negative affect was slightly higher than the mean score of the norm sample ($M = 1.60$) at the beginning of the intervention (Crawford & Henry, 2004), the decrease in negative affect was especially relevant. Regarding the

relation between the change in physical activity and the change in impaired well-being, the parallel process growth modelling showed that the increase in number of steps was related to the decrease in negative affect. However, no such association was found for the increase in number of steps and the decrease in emotional strain. Regarding the question of what time point the mHealth intervention started to yield an effect, LCS showed that employees required one intervention week before they significantly increased their number of steps. Additionally, a further intervention week was needed before employees showed a significant decrease in emotional strain and negative affect.

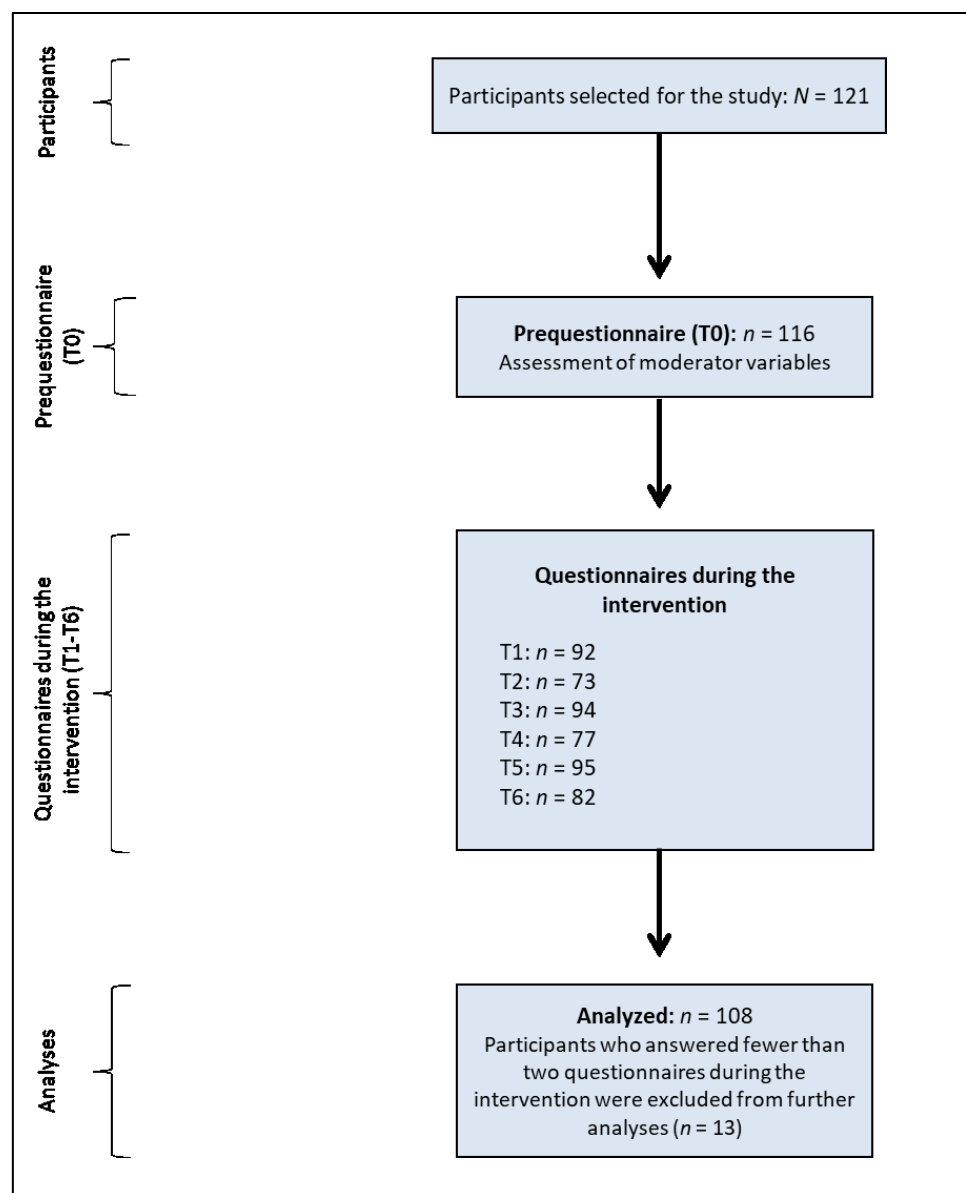


Figure 7. Participation and allocation in Study 2 inspired by the Consort diagram.

Chapter 5

General Discussion

Given that physical inactivity is regarded as one of the biggest public health problems of the 21st century and that jobs are predicted to become increasingly sedentary (Blair, 2009; Clemes et al., 2014; Hendriksen et al., 2016), this dissertation aimed to evaluate the efficacy of an intervention including activity trackers as a promising new technology to foster physical activity in the occupational context. Both studies of this dissertation examined the effectiveness of a cognitive-behavioral mHealth intervention using various outcome measures and different methodological approaches. Thus, the following sections will discuss the findings of Study 1 and Study 2 and their theoretical, methodological, and practical implications.

5.1. Theoretical Implications

The purpose of the following section is to discuss the findings of this dissertation from a theoretical perspective. In particular, the developed OHBC model will be critically reviewed and revised under consideration of the studies' results.

5.1.1. The Motivational and Volitional Phase

The OHBC model proposes that motivation and planning are essential factors for successfully changing health behavior among employees. In the motivational phase, employees should be motivated for health behavior change so that they develop an intention to change a certain health behavior (e.g., increase their physical activity; see Chapter 3.1). Subsequently, this intention should be transferred into actions by means of action planning and coping planning in the volitional phase (see Chapter 3.2). In the studies of this dissertation, activity trackers were implemented to motivate employees to become physically active and an online coach provided advice with the goal of helping employees to translate their intentions into actions. Study 1 showed that these techniques were effective in increasing employees' physical activity compared to a group of employees who received no treatment.

This result is in line with previous studies which have shown that activity trackers as well as action and coping planning are effective in increasing physical activity (Cadmus-Bertram, Marcus, Patterson, Parker, & Morey, 2015; Wiedemann et al., 2011; Williams & French, 2011; Ziegelmann et al., 2006). On a more detailed level, Study 2 examined the development of the number of steps during the intervention and showed that employees required one intervention week before they significantly increased their number of steps. The pattern of change in the number of steps revealed by Study 2 suggests that the step challenge in the second intervention week was especially successful in motivating employees to increase their number of steps (see Study 2 in the Appendix). As social challenges and competitions are an effective technique for increasing physical activity (Foster, Linehan, Kirman, Lawson, & James, 2010; Leininger, Orozco, & Adams, 2014; Prestwich et al., 2017), future studies might also include challenges in order to promote physical activity among employees. Additionally, Study 1 indicated that the activity tracker is a useful tool for motivating employees to change their health behavior sustainably since 84.2% of the employees still used the device three months after the intervention and 74.3% still used the activity tracker one year after the intervention.

To summarize, both studies showed that the applied intervention techniques (i.e., activity tracker and online coach) were effective in motivating employees to increase their physical activity. Thus, the motivational phase and volitional phase of the OHBC model constitute a reasonable framework for future intervention studies to promote health behavior change in the occupational context. However, the studies of this dissertation did not differentiate between the two phases of the model. Although empirical evidence confirms the stage concept of the HAPA model on which the OHBC model is based (e.g., Lippke, Ziegelmann, & Schwarzer, 2005; Parschau et al., 2012), future studies should analyze the motivational phase and volitional phase separately.

5.1.2. The Action Phase

In the action phase of the OHBC model, the actual health behavior change is practiced by the employee who shows the desired health behavior. Additionally, the action phase includes work-related and personal resources which could further facilitate health behavior change (see Chapter 3.3). However, the results of Study 2 showed that neither job control as a job resource nor self-efficacy as a personal resource influenced the increase in number of steps during the intervention. Viewed positively, the mHealth intervention was effective regardless of work-related or personal factors.

Nonetheless, a reason why job control did not show an effect on the intervention's efficacy could be the design of the mHealth intervention. In a study by Cifuentes et al. (2015), which showed a positive effect of job control on the effectiveness of a treadmill workstation intervention, the intervention could only be performed at work. In contrast, activity trackers are easily accessible (can be used anywhere, at any time) which also applies to the online coach which could be used on a smartphone (Borrelli & Ritterband, 2015). Thus, it is possible that employees also performed the intervention outside of work undermining the potential positive effect of job control.

Due to the special characteristics of mHealth interventions, other work characteristics might be more important when implementing interventions which include elements such as activity trackers or online coaches. Given the digital nature of these elements, it might be more relevant to consider digital work characteristics such as information and communication technology (ICT) demands rather than examining more traditional work characteristics (e.g., job control). For example, employees who have to review a large amount of technology-based information at work might experience an information overload (Day, Paquet, Scott, & Hambley, 2012; Edmunds & Morris, 2000; Tarafdar, Tu, & Ragu-Nathan, 2010), so that fewer resources are available for tasks requiring further information processing. Thus, it might be possible that these employees are less likely to be motivated to engage in

intervention activities in which they have to process information related to their health behavior (e.g., interventions including activity trackers). Additionally, research has shown that high ICT demands result in a negative attitude towards technology (Fuglseth & Sørebo, 2014; Tarafdar et al., 2010), which could further reduce the efficacy of interventions including mHealth elements. Hence, the influence of technology-specific job demands could be addressed by future studies on mHealth interventions. To address this factor, I revised the OHBC model and included job demands as an additional factor which might influence employee's health behavior change (see Figure 8).

Regarding self-efficacy, Study 2 revealed no effect of self-efficacy on employees' increase in number of steps. A possible explanation could be that the mHealth intervention itself increased self-efficacy among employees. Previous studies have shown that some of the techniques used in the intervention such as self-monitoring or action planning also benefit self-efficacy (Gleeson-Kreig, 2006; Olander et al., 2013; Williams & French, 2011). Hence, the intervention might not only have improved employees' physical activity but may also have increased their self-efficacy regarding physical activity. Additionally, previous studies have shown that 38-63% of the variance in self-efficacy fluctuates on a daily basis (Tims, Bakker, & Xanthopoulou, 2011; Xanthopoulou, Bakker, Heuven, Demerouti, & Schaufeli, 2008). In Study 2, self-efficacy was only measured before employees engaged in the intervention activities. Thus, it is possible that no effect of self-efficacy on the increase of the number of steps was found because self-efficacy fluctuated during the intervention.

However, since previous research has shown that personal resources are relevant for health behavior change and Study 2 possibly found no effect due to the explanations pointed out above (Bauman et al., 2012; Pedersen et al., 2013; Prodaniuk et al., 2004; Stutts, 2002; Williams & French, 2011), personal resources should still be incorporated in the OHBC model (see Figure 8).

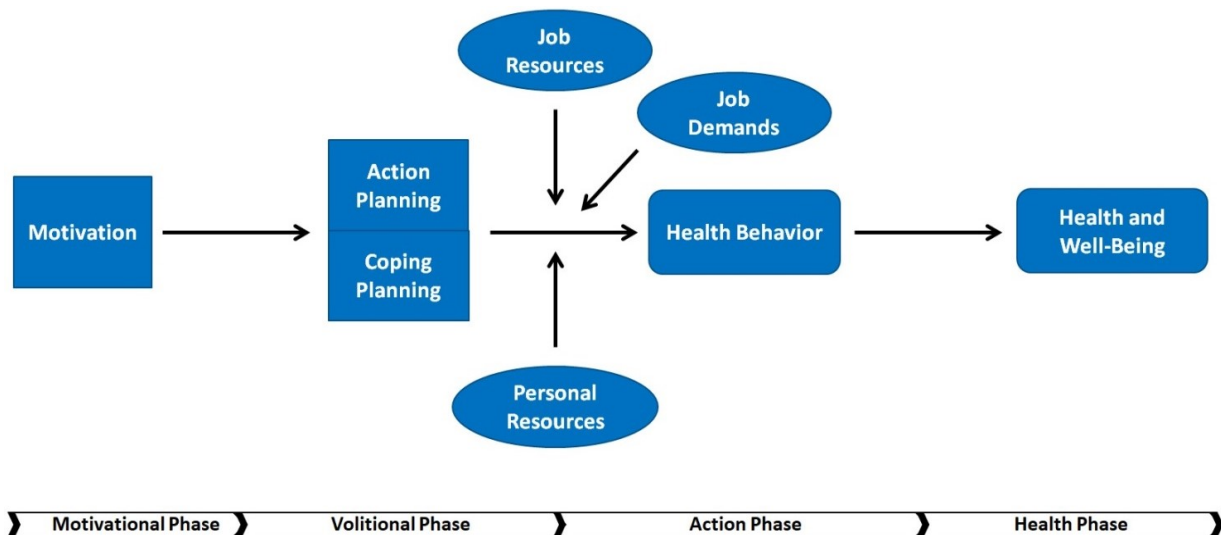


Figure 8. Illustration of the revised OHBC model.

5.1.3. The Health Phase

In health phase of the OHBC, employees benefit from their change in health behavior in the form of an improvement in different health indicators (see Chapter 3.4). In the studies of this dissertation, the effect of an intervention with activity trackers was examined on different indicators of health and well-being. Study 1 showed that especially physical health indicators (i.e., BMI and health perception) were improved by promoting physical activity, whereas no effect was found for the considered well-being outcomes (i.e., burnout and vigor). However, the results of Study 2 revealed that the mHealth intervention reduced emotional strain, as a less severe stress indicator, and negative affect. as a non-work-related well-being indicator. A reason why except for emotional strain no effect was found regarding work-related well-being might be the context-specific nature of the constructs. According to the triple-match principle (TMP), variables are more likely to be associated when concepts are based on qualitatively identical dimensions (De Jonge & Dormann, 2003, 2006). For instance, an insolent customer most likely evokes emotional disorders than physical health complaints (De Jonge & Dormann, 2006). Therefore, in the context of the two studies, it might be possible that the intervention improves work-related indicators less directly than other health and well-being

indicators because the intervention elements do not address work-related aspects in particular. Thus, a large amount of physical activity might be necessary to improve indicators that are less directly associated with being physically active (e.g., indicators of work-related well-being). This explanation is supported by a study showing that only employees engaging intensively in physical activity (i.e., yoga workouts) improved their vigor (Strijk, Proper, van Mechelen, & van der Beek, 2013). Furthermore, it might be possible that a large amount of physical activity is necessary to improve more severe well-being indicators (e.g., burnout). Future studies could investigate the amount and intensity of physical activity needed to improve work-related and more severe well-being indicators.

In summary, promoting physical activity with activity trackers combined with an online coach improved employees' health (i.e., health perception and BMI) and well-being (i.e., emotional strain and negative affect). Thus, Study 1 and Study 2 supported the theoretical assumption of the OHBC model that health behavior change leads to a health improvement in employees (see Figure 8).

5.2. Methodological Implications

Besides the theoretical implications, the studies of this dissertation contribute methodologically to the existing literature in several ways. In the following section, the methodological implications of this dissertation will be discussed.

5.2.1. Sample and Recruitment Procedure

The two studies of this dissertation are among the first studies to examine the effect of an intervention with activity trackers on health and health behavior in a sample of employees. The sample for both studies was recruited from one large enterprise in Germany. Due to this recruitment procedure, me and my colleagues were able to access a special population of mainly low active employees at risk. In most physical activity intervention studies conducted

in the workplace, participants tend to be healthier than non-participants (Waters, Galichet, Owen, & Eakin, 2010). For instance, one of the few studies that examined the effect of activity trackers on employees' health assumed that participants who were healthier than the average employee were probably recruited (Finkelstein et al., 2016). Both studies of this dissertation included employees at high risk in terms of health-related factors. Even though these employees are in need to improve their health behavior, they are rarely considered in health interventions. Hence, the found intervention effects are especially relevant since previous research has shown that it is challenging for workplace health interventions to sustain engagement levels and achieve positive health behavior change among employees at risk (Muir et al., 2019). A reason for this difficulty might be that most workplace physical activity interventions to date have exposed employees to the exact same program regardless of their motivation or activity level (Muir et al., 2019). Given that the activity tracker is highly tailorable, its use in this mHealth intervention might have caused the positive effects in both studies, since even inactive employees at risk could customize the content of the activity tracker to suit their individual motivation and needs.

Besides this aspect, the samples of Study 1 and Study 2 are different from those of previous physical activity studies in further ways (Waters et al., 2010). Waters et al. (2010) showed that most employees engaging in physical activity interventions appeared to be more educated. In the sample of the studies of this dissertation, however, the majority of employees had acquired vocational training or completed lower secondary education. Additionally, the participants were predominantly male, whereas most previous physical activity intervention studies recruited more female participants (Waters et al., 2010). Previous research indicates that especially men show interest and a positive attitude towards technology (Cai, Fan, & Du, 2017; Ellis et al., 2012; Su, Rounds, & Armstrong, 2009). Thus, the use of activity trackers as a technology in this intervention might have motivated men in particular to participate in the studies. Future workplace interventions targeting male employees might therefore include

technological approaches to encourage men to engage in intervention activities (Ellis et al., 2012). Besides gaining access to an underrepresented population of employees within workplace physical activity interventions, recruiting at one company naturally controlled for variance (e.g., company size, management behavior, etc.) which might have been statistically kept constant instead.

A further methodological implication regarding the sample size was revealed by Study 2. Given that no previous studies had evaluated the effectiveness of an mHealth intervention combining activity trackers and an online coach among employees, calculating the optimal sample size was not possible. Nevertheless, one meta-analysis which examined the effect of pedometers (predecessor of activity trackers; i.e., a device that simply tracks steps and no further health-related data) on the number of steps in a non-workplace setting yielded an effect size of 0.84 (Kang, Marshall, Barreira, & Lee, 2009). However, in Study 2, much smaller effect sizes were found compared to in the meta-analysis of Kang et al. (2009), which did not reach significance in our sample despite the high-quality of the data (e.g., objectively reported activity data). A recent study showed that meta-analyses tend to overestimate effect sizes which might be a reason for this discrepancy (Kvarven, Strömmland, & Johannesson, 2019). Thus, future studies should consider that a large sample size is needed when aiming to detect smaller effects, even though high-quality data allow for higher precision. Additionally, the effects found in the studies of this dissertation could serve as a guideline for calculating the optimal sample size for future high-powered replication studies.

5.2.2. Study Design and Analysis Techniques

Even though there are physical activity intervention studies available, there is still a great need for high-quality studies using an RCT design among employees and for studies capturing long-term effects exceeding several weeks (Hutchinson & Wilson, 2012; Malik et al., 2014; Naczenski, Vries, van Hooff, & Kompier, 2017; Rongen et al., 2013; Tam & Yeung, 2018).

Especially, studies examining the long-term effects of activity trackers are rather scarce (Cadmus-Bertram et al., 2015). To address this lack of research, Study 1 used an RCT design and assessed the possible long-term effects of the intervention one month, three months, and one year after the intervention. However, me and my co-authors only had access to the intervention group to assess the long-term effects. Thus, it is desirable that future studies examine long-term effects by comparing employees who engaged in the intervention activities with a control group of employees who received no treatment.

Even though through the RCT design, me and my colleagues were able to draw causal conclusions on the intervention's effectiveness, Study 1 provided no information about what was happening during the intervention. To shed new light on this question, Study 2 examined the change in number of steps and impaired well-being during the intervention using modern analytical techniques such as LGCM and LCS. LGCM is a flexible method for estimating inter-individual variability in intra-individual patterns of change overtime whereas LCS can model change using only two points of measurement (Curran et al., 2010; McArdle, 2009; Selig & Preacher, 2009). Especially the combination of these analytical approaches answered several questions that had not previously been addressed by interventions including activity trackers. Thus, Study 2 provided information about the relationship between the variables, showing that the change in number of steps is related to the change in impaired well-being (i.e., negative affect) during the intervention. Furthermore, LGCM showed that there is significant variance in the slope for the employees' number of steps (see Study 2 in the Appendix). For future studies with a larger sample size it might be interesting to explain this variance by identifying groups of employees who exhibit a similar change in behavior during the intervention by means of latent class analysis (Nylund, Asparouhov, & Muthén, 2007).

Besides these findings, Study 2 identified the time points when the mHealth intervention started to yield an effect. The results showed that employees required one intervention week before they could significantly increase their number of steps and about two weeks before

they improved their impaired well-being. To the best of my knowledge, this is the first study to examine the temporal aspect of an intervention using activity trackers to improve employees' physical activity and impaired well-being. This finding has important implications for the design of future intervention studies, since it reveals that employees require some time to improve their physical activity and impaired well-being. Thus, future studies should factor in some time for an intervention effect to be measurable. In summary, the combination of a strong study design with modern analytical techniques, allowed for the comprehensive examination of an intervention with activity trackers and unveiled different methodological implications for future studies.

5.3. Practical Implications

This dissertation has shown that activity trackers combined with an online coach are effective in increasing physical activity and improving different health and well-being indicators among employees. Besides the direct effect on the health and health behavior of employees, the evaluated mHealth intervention is valuable for employers, since the improved indicators are associated with organizational outcomes such as positive effects on performance, job satisfaction, and absenteeism (Bowling, Eschleman, & Wang, 2010; Fang, Huang, & Hsu, 2019; Finkelstein, DiBonaventura, Burgess, & Hale, 2010; Jamal, 2011; Parks & Steelman, 2008; Roelen, Koopmans, Graaf, van Zandbergen, & Groothoff, 2007; van Nuys et al., 2014). Given that activity trackers are not costly and the online coach could be programmed to include considerable resources, this mHealth intervention could be an efficient investment for employers to improve employees' health and well-being and in turn reduce health care costs in the long-term.

Furthermore, especially activity trackers present several advantages for organizations over more traditional intervention techniques (e.g., professional fitness trainers) for fostering physical activity among employees. It is particularly difficult for decentralized organizations

or companies with employees working in shifts to implement traditional health interventions (e.g., hiring fitness trainers) since it is nearly impossible and not economical to bring together a large amount of employees in one location. Activity trackers offer an opportunity to reach all employees of these organizations since they can be used regardless of the employee's location at any time (Borrelli & Ritterband, 2015). Although activity trackers are a valuable means of promoting occupational health, there might still be some concerns in relation to this technology. To address these concerns and facilitate the implementation of activity trackers by practitioners, I will discuss some possible reservations in the following sections.

5.3.1. Activity Trackers and Elderly Employees

As a result of demographic change, the average age of employees is constantly increasing within organizations (Köchling, 2003; Streb, Voelpel, & Leibold, 2008). Regarding new technologies, there is a prevalent preconception that older adults struggle to use digital tools. Thus, it could be assumed that activity trackers are not an appropriate intervention for increasing physical activity among elderly employees. In the studies of this dissertation, employees' age ranged from 19 to 62 years. Due to the self-selection recruitment procedure, the age range already indicates that a technology-based intervention attracts employees of all ages. Additionally, previous research has revealed that activity trackers include behavior change techniques such as self-monitoring and rewards which have been shown to be effective in increasing physical activity among older adults (Chase, 2013; Conn, Valentine, & Cooper, 2002; French, Olander, Chisholm, & Mc Sharry, 2014; Mercer, Li, Giangregorio, Burns, & Grindrod, 2016). In line with these findings, a recent meta-analysis of intervention studies using activity trackers showed that these devices are effective in increasing older adults' physical activity (Oliveira, Sherrington, Zheng, Rodrigues Franco, & Tiedemann, 2019). A reason for this positive effect might be that activity tracker are easy to use for older adults (McMahon et al., 2016; O'Brien, Troutman-Jordan, Hathaway, Armstrong, & Moore,

2015). Due to the high usability of activity trackers, older adults do not require a special training or instructions to use these devices (Rasche et al., 2015; Rasche et al., 2016). Compared to a smartphone app, older adults even prefer to monitor their physical activity with activity trackers, since they find them more convenient (Kupffer, Wutzler, Krems, & Jahn, 2018). Thus, activity trackers are equally usable by younger and older adults which make them an effective technology for occupational health promotion independent of the age of the targeted group of employees (Rasche et al., 2016).

5.3.2. Data Security and Ethics

Activity trackers collect sensitive personal data which provide a detailed insight into the health behavior and health status of their users. Hence, data security is an important aspect which needs to be considered when implementing activity trackers in research designs or occupational health programs. Regarding this dissertation, the company's work council and the data protection officer were involved in both studies at all times. Additionally, the requirements of the declaration of Helsinki were rigorously followed (World Medical Association, 2013).

Recently, the German Data Forum published a data protection guideline for research using apps and wearables to collect data (Rat für Sozial- und Wirtschaftsdaten, 2020). As activity trackers collect a large amount of data which are connected to each other, securing participants' anonymity can be challenging (Langheinrich & Schaub, 2018; Miller, 2012). To minimize the possibility of revealing participants' identity, indirect data such as the Global Positioning System signal (GPS signal) should not be collected if this type of data is not explicitly necessary for answering research questions (Rat für Sozial- und Wirtschaftsdaten, 2020). Additionally, the processing of data (e.g., storage of data) should be critically reviewed when using activity trackers. For instance, registered data by activity trackers are most commonly stored on smartphone apps, which could facilitate hacking of personal health data

(Carter, Liddle, Hall, & Chenery, 2015). To avoid security gaps of smartphone technology, it is recommended that encryption techniques are used for storing, processing and transferring data (Carter et al., 2015; Rat für Sozial- und Wirtschaftsdaten, 2020). Lastly, it is important to adequately inform participants about how their data are collected, stored, and analyzed (Rat für Sozial- und Wirtschaftsdaten, 2020). As activity trackers collect a large amount of different data, participants might not be fully aware of all the data the device is gathering (Hoy, 2016). To inform participants about data processing, a balance needs to be found between the complexity of the process and the participants' ability to comprehend this process, since participants might struggle to understand a very detailed description (Carter et al., 2015). Thus, it is recommended that visualization techniques (e.g., video sequences) are used to explain the study's data processing approach and to facilitate participants' understanding of it (Carter et al., 2015). Provided that these recommendations are taken into consideration, activity trackers constitute a valuable technology for researchers as they provide convenient access to objectively measured health data which are usually difficult to assess.

Data security plays an equally important role for the implementation of activity trackers in occupational health programs as in the context of research. Employees are in a relation of dependence with their employers which is why employers should ensure data security with regard to occupational health programs. Accomplishing data security is of particular importance, since previous studies have shown that a potential perceived privacy risk does not prevent users from using activity trackers (Rheingans, Cikit, & Ernst, 2016). Thus, it is highly recommended that employers also follow the previously stated recommendations of the German Data Forum (Rat für Sozial- und Wirtschaftsdaten, 2020). To increase employees' acceptance, employers should furthermore involve the company's work council or the employees' representative before including activity trackers in their occupational health program.

Figure 9 shows a flow diagram based on the recommendations of the German Data Forum and my experience of conducting a study with activity trackers (Rat für Sozial- und Wirtschaftsdaten, 2020). The flow diagram might function as a guideline to facilitate researchers' and employers' decisions on how to handle data security regarding activity trackers. However, it is always advisable that a data security officer reviews the specific details of a research design or of an occupational health program aiming to implement activity trackers.

5.4. Limitations and Directions for Future Studies

Even though this dissertation has several advantages (e.g., use of an RCT design, assessment of long-term effects, application of modern analytical techniques), the studies of this dissertation are not without limitations which should be addressed in future studies. The RCT design allowed drawing causal conclusions on the effectiveness of the intervention. However, the CG was not available for the assessment of the long-term effects. Additionally, Study 2 did not include a CG. Thus, future studies examining long-term effects and the trajectory of outcomes during an mHealth intervention should include a CG in their study designs.

Furthermore, as mentioned in Chapter 5.2.2, this dissertation reveals the time points at which employees experience a benefit in their well-being from engaging in an mHealth intervention. This aspect is especially interesting for employers with regard to occupational health promotion. Hence, future studies should further examine the amount of time needed before health behavior change results in an improvement of health and well-being by considering different outcome measures. With regard to the outcome measures considered

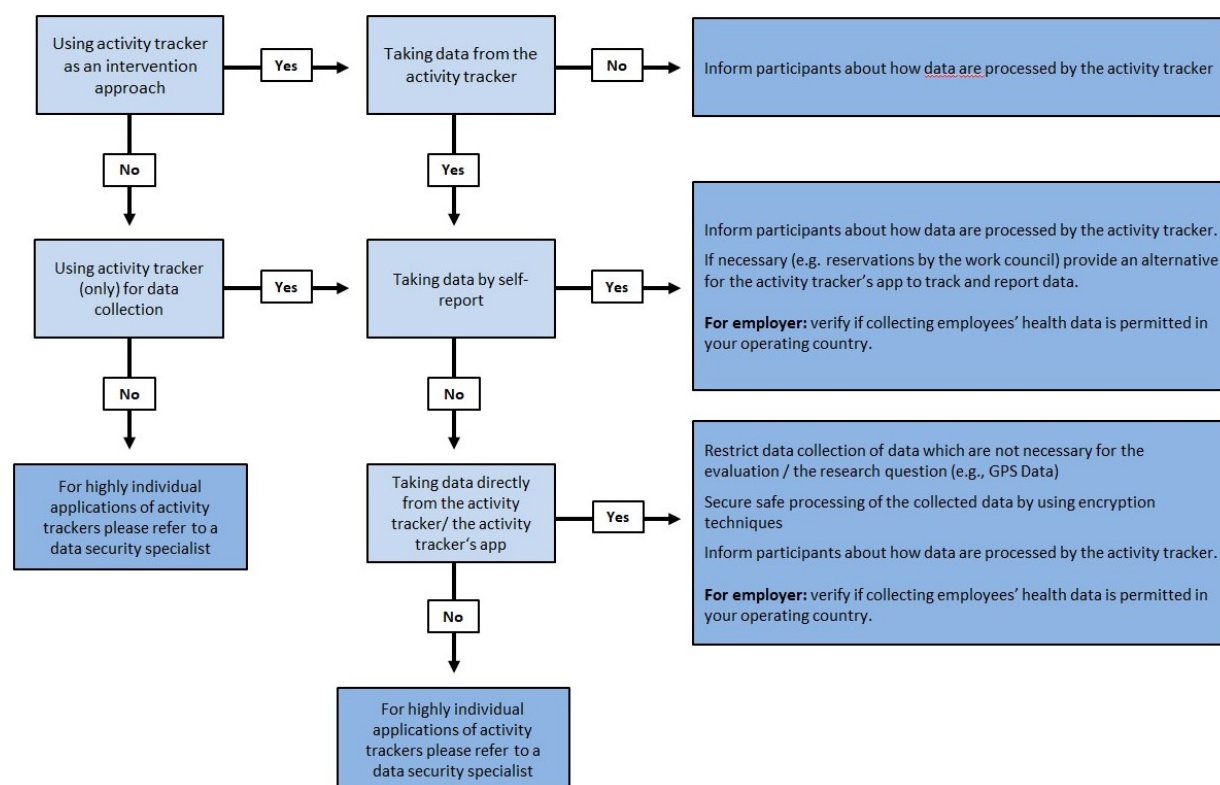


Figure 9. Flow diagram showing how to handle the data security of activity trackers.

in this dissertation, the mHealth intervention showed a positive effect on physical activity, BMI, health perception, emotional strain, and negative affect. Nevertheless, it is not possible to determine which of the intervention's elements are responsible for improving employees' physical activity, health, and well-being. Activity trackers offer various features which could have had a differentially strong impact on the outcome measures. For instance, regarding the number of steps, Study 2 indicated that the step challenge conducted in the second intervention week might be especially effective in increasing physical activity among employees. Thus, future studies should examine which intervention elements are particularly successful in improving employees' health and health behavior or whether a combination of the different elements is necessary for achieving positive effects.

5.5. Conclusion

This dissertation aimed to evaluate the effectiveness of an mHealth intervention combining activity trackers with an online coach within the framework of the newly created OHBC model. Study 1 and Study 2 showed that the mHealth intervention was effective in increasing subjectively and objectively measured physical activity among inactive employees at risk. However, Study 2 revealed that the increase in physical activity was not moderated by job control or self-efficacy, which might be due to the specific design of the intervention. Thus, this dissertation suggests including different work characteristics (e.g., ICT demands) when evaluating mHealth interventions, which is why the OHBC model was expanded to include job demands. With regard to the health phase, the intervention was found to have positive effects in relation to the improvement in health (i.e., BMI and health perception), a more sensitive stress indicator (i.e., emotional strain) and non-work-related well-being (i.e., negative affect). However, the mHealth intervention was not effective in improving work-related well-being (i.e., burnout and vigor). Future studies might examine what amount and intensity of physical activity is needed to increase well-being indicators which might be less directly affected by physical activity. Nevertheless, the results of both studies largely confirmed the theoretical assumptions of the OHBC model. Besides verifying the OHBC model, the studies of this dissertation applied modern analytical approaches to make a methodological contribution to the existing literature on workplace interventions. In this way, it answered further questions about the time point when an intervention starts to yield an effect and about the relationship between the change in employees' physical activity and well-being. In summary, this dissertation has shown that a cognitive-behavioral mHealth intervention with activity trackers is effective in improving physical activity, health, and well-being among inactive employees at risk.

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Appendix

Improving Employees' Work-Related Well-Being and Physical Health through a Technology-
Based Physical Activity Intervention: A Randomized Intervention-Control Group Study¹

Thomas Lennefer¹, Elisa Lopper¹, Amelie U. Wiedemann², Ursula Hess¹, and Annekatrin
Hoppe¹

¹Department of Psychology, Humboldt-Universität zu Berlin, Rudower Chaussee 18, 12489
Berlin, Germany

²DearEmployee LLC, Laurinsteig 34, 13465
Berlin, Germany

Correspondence concerning this article should be addressed to Thomas Lennefer,
Department of Psychology, Humboldt University of Berlin, Rudower Chaussee 18, 12489
Berlin, Germany, E-Mail: thomas.lennefer@hu-berlin.de

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Abstract

Although activity trackers are becoming more popular, little is known whether this new technology qualifies to improve employees' health. This study aimed to evaluate the effect of a workplace intervention applying activity trackers (behavioral approach) along with an online coach (cognitive approach) on work-related well-being (e.g., burnout) and physical health (e.g., body mass index). To test for intervention effects, 116 employees at risk were recruited at one large mobility enterprise in Germany and randomly assigned to an intervention group ($n = 59$) and a control group ($n = 57$). Intervention effects were assessed one month, three months and one year after the intervention. Analyses of variance for repeated measures revealed no intervention or long-term effects on work-related well-being. In the intervention group we found a significant increase in health perception and a significant decrease in body mass index. These effects were stable over time three months after the intervention for health perception and one year after the intervention for body mass index. Our study shows that a cognitive-behavioral intervention with activity trackers improved physical health over time but was not effective in enhancing work-related well-being.

Keywords: randomized control group design, workplace health promotion, burnout, employees' health, activity trackers

Introduction

Physical activity is defined as any bodily movement produced by skeletal muscles that results in energy expenditure (Caspersen, Powell, & Christenson, 1985). Previous research has shown that physical activity has a major impact on various physical and mental health outcomes (Reiner, Niermann, Jekauc, & Woll, 2013; Warburton, Nicol, & Bredin, 2006). For example, physically active employees show a lower level of burnout and feel more vigorous during working hours. (ten Brummelhuis & Bakker, 2012; Jonsdottir, Rödger, Hadzibajramovic, Börjesson, & Ahlborg, 2010). As regards physical health, it has been shown that physical activity is associated with a more positive perception of employees' health (Bogaert, Martelaer, Deforche, Clarys, & Zinzen, 2014) and leads to a decrease in employees' body mass index (BMI; Anderson et al., 2009). Given these consistent positive effects, different worksite interventions have been implemented to increase employees' physical activity. In their meta-analysis Taylor, Conner, and Lawton (2012) showed that worksite interventions could increase employees' physical activity with a small effect size ($d = .21$). Most studies focused either on a cognitive (e.g., Spittaels, Bourdeaudhuij, Brug, & Vandelanotte, 2007) or a behavioral approach (e.g., Schuna et al., 2014). However, Hutchinson and Wilson (2012) pointed out, that there is encouraging evidence from one intervention study combining cognitive and behavioral approaches for increasing physical activity with a large effect ($d = .90$). Even though intervention studies are available, there is still a great need for sound randomized controlled intervention studies with employees (Rongen, Robroek, van Lenthe, & Burdorf, 2013) and for studies focusing on long-term effects exceeding several weeks (Hutchinson & Wilson, 2012).

In this study we tested whether a combined cognitive-behavioral intervention would improve employees' work-related well-being (i.e., burnout and vigor) and physical health (i.e., health perception and BMI). The effectiveness of the intervention was examined using a randomized control group design (RCT design) with employees in one company. We

moreover tested for long-term effects within the intervention group one month, three months, and one year after the intervention. During the intervention employees received an activity tracker as a behavioral approach to monitor their physical activity (e.g., number of steps taken). Activity trackers are new technology which might be interesting for occupational health promotion since they are cost-effective and easy accessible (can be used anywhere, at any time; Borrelli & Ritterband, 2015). Due to these advantages, activity trackers can be easily integrated into daily work routines since employees are able to use them whenever or wherever in their spare time at work. To further raise awareness and motivation for health behavior change, we implemented an online coach as a cognitive approach offering advice on health behavior change (e.g., how to set health behavior goals).

Overall, our study advances the literature in several ways. First, we evaluate the effectiveness of an activity tracker based intervention, which broadens the theoretical understanding of a new technology for health behavior change. By investigating the effect on work-related well-being (i.e., burnout and vigor) and physical health (i.e., body mass index and health perception), we consider new outcome measures, since so far research including activity trackers has concentrated solely on non-work-related outcomes. Second, we focused specifically on employees at risk recruited at one large enterprise in Germany. This allowed us access to a population of physically inactive employees at risk who are usually difficult to approach. Finally, the effectiveness of the intervention was assessed using a RCT design, which enables us to draw causal conclusions on the effects of the intervention. Due to the limited evidence of the long-term effects of activity trackers (Cadmus-Bertram, Marcus, Patterson, Parker, & Morey, 2015), multiple points of measurement were considered. This enabled us to evaluate the sustainability of a possible intervention effect one month, three months, and one year after the intervention.

Theoretical Background, Previous Empirical Investigations and Hypotheses

Work-Related Well-Being

Burnout. Burnout is considered as an affective reaction occurring due to exposure to prolonged stress at work (Shirom, Melamed, Toker, Berliner, & Shapira, 2005). According to Shirom (1989), burnout is a multidimensional construct characterized by a combination of physical fatigue, emotional exhaustion and cognitive weariness (Shirom, Nirel, & Vinokur, 2006). Employees experiencing physical fatigue are tired and lack energy to manage daily tasks at work. Emotional exhaustion is defined as the feeling of being too weak to invest in relationships with colleagues or clients (e.g., displaying empathy). Cognitive weariness refers to one's feelings of thinking slowly and a reduction of mental agility (Melamed, Shirom, Toker, Berliner, & Shapira, 2006; Shirom et al., 2006).

Besides these negative consequences for the employee, burnout also entails disadvantages for the employer due to its association with absenteeism (Duijts, Kant, Swaen, van den Brandt, & Zeegers, 2007; Petitta & Vecchione, 2011) and a decline in performance (Dewa et al., 2014; Swider & Zimmerman, 2010; Taris, 2006).

Promoting physical activity can function as an effective intervention to reduce burnout. For instance Tsai et al. (2013) implemented a 12-weeks exercise program at a bank and insurance company. One hundred and nine employees were randomly assigned to a low-intensity exercise group, a high-intensity exercise group, or a control group. The low intensity group participated in exercise sessions led by a professional trainer once a week, whereas the high intensity group took these sessions twice a week. The control group did not engage in any of the exercise sessions, they had to plan and carry out exercise regimes on their own. The results revealed that after the intervention participants' burnout was significantly lower than before the intervention for both intensity groups. Further studies supported the effectiveness of workplace interventions promoting physical activity to alleviate burnout (Bretland & Thorsteinsson, 2015; Gerber et al., 2013). Nevertheless, these studies had some limitations.

Besides not considering possible long-term effects, two of these studies included relatively small sample sizes (Gerber et al. (2013): $n = 12$; Bretland & Thorsteinsson (2015): $n = 49$). Regarding long-term effects, van Rhenen, Blonk, van der Klink, van Dijk, and Schaufeli (2005) tested the effectiveness of an intervention involving relaxation and physical exercise directly after the intervention period and at six-week follow-up. The results showed that employees had a lower burnout level after the intervention. Moreover, a persistent reduction of burnout at six-month follow-up could be found as well. However, this study did not include a control group, which is why it is not possible to draw causal conclusions. Therefore, Naczenski, Vries, van Hooff, and Kompier (2017) pointed out that there is still a lack of high-quality long-term intervention studies investigating the influence of physical activity on burnout.

Vigor. Vigor is one core component of work engagement according to Schaufeli, Bakker, and Salanova (2006). It can be defined as high levels of energy and mental resilience at work. Vigorous employees invest effort in their work and persist even in the face of difficulties (Schaufeli et al., 2006). As this definition implies, vigor is a conceptual opposite to emotional exhaustion which is a core dimension of burnout (González-Romá, Schaufeli, Bakker, & Lloret, 2006).

So far only a few studies have tested whether employees' vigor can be enhanced through physical activity interventions. While being physically active, various physiological reactions are caused within the body (e.g. endorphin release; Mikkelsen, Stojanovska, Polenakovic, Bosevski, & Apostolopoulos, 2017). One of these physiological mechanisms could particularly be related to vigor. Physiologically, physical activity is perceived by the body as a stressor (Anderson & Wideman, 2017), thus being physically active releases a high level of cortisol into the body resulting in an increased cortisol concentration (Gomes de Souza Vale, Rodrigo et al., 2012). As one function of cortisol is to obtain energy by promoting gluconeogenesis (Gomes de Souza Vale, Rodrigo et al., 2012), it is likely that

increased cortisol level enhances vigor. Cortisol was indeed found to reduce fatigue and increase vigor directly, as shown by Tops, van Peer, Wijers, and Korf (2006). Participants who received cortisol capsule showed less fatigue and more vigor than did participants receiving a placebo. Moreover, cortisol is a hormone which helps the organism to adapt to stress or exertion (Anderson & Wideman, 2017). Accordingly, regular physical activity accelerates recovery from stress reaction (Jackson & Dishman, 2006; Teisala et al., 2014). In sum, it can be assumed that physical activity has a positive effect on vigor via increased cortisol concentration in the short term and reduced stress reaction in the longer term, which together results in higher vigor.

This assumption has been supported by Hansen, Blangsted, Hansen, Sogaard, and Sjøgaard (2010), who showed that physically active employees generally feel more energetic. Additionally, they found that employees who were physically active during their leisure time showed higher cortisol levels in the evening, which was associated with higher perceived energy. These results can also be supported by ten Brummelhuis and Bakker (2012), who showed that being physically active after work increased employees' vigor in the following morning. Pronk, Katz, Lowry, and Payfer (2012) conducted an intervention to enhance activity at work by reducing sitting time. The results showed that employees in the intervention group felt more vigorous after the intervention than did employees in the control group.

Nevertheless some studies have found no association between physical activity and vigor (Isoard-Gauthier, Scotto-di-Luzio, Ginoux, & Sarrazin, 2018; Strijk, Proper, van Mechelen, & van der Beek, 2013; van Berkel et al., 2013). Van Berkel et al. (2013) assume that they found no effect as their participants were not sufficiently physically active. This is supported by the fact that a rise in cortisol only occurs if the physical activity is strenuous for the individual (Anderson & Wideman, 2017; Gomes de Souza Vale, Rodrigo et al., 2012). As Strijk et al. (2013) found that only participants who were extremely complied in activities to

increase physical activity showed an increase in work-related vitality, while less compliant participants showed no intervention effect. Based on this evidence we conducted an intervention focusing on moderate to vigorous physical activity.

In light of the foregoing we assume that a cognitive-behavioral intervention with activity trackers would improve work-related well-being. We therefore hypothesize:

Hypothesis 1: Employees in the intervention group show lower levels of burnout after the intervention than employees in the control group.

Hypothesis 2: Employees in the intervention group show higher levels of vigor after the intervention than employees in the control group.

Physical Health

Health Perception. Health Perception is defined as individuals' subjective perceptions of their own health status (Benyamini, 2012). Even though these perceptions are not always medically accurate (Benyamini, 2012), they serve as an important measure since they integrate several relevant health factors such as physiological factors, symptom status, and functioning (Havranek et al., 2001; Wilson, 1995). As earlier studies have shown, health perception is a strong predictor for mortality (DeSalvo et al., 2006), which makes it a useful health outcome measure (Burstrom, 2001). Moreover, employees' health perception is relevant since it is associated with job absenteeism (Roelen et al., 2007), work ability (Rongen, Robroek, Schaufeli, & Burdorf, 2014), and employee's performance (van Scheppingen et al., 2013).

Given that health perception is related to bodily sensations and symptoms which may reflect diseases in their clinical and pre-clinical stages (Benyamini, 2011), it is likely that physical activity which lowers the risk for several diseases (Jeon, Lokken, Hu, & van Dam, 2007; Li & Siegrist, 2012; Mammen & Faulkner, 2013), also has a positive effect on health perception. This assumption has been supported by several studies. For instance, Bogaert et al. (2014) showed in a population of secondary school teachers that teachers who were

physically active during their leisure time reported more positive perceived health. Okano, Miyake, and Mori (2003) surveyed various lifestyle factors (e.g., nutritional status and physical activity) and their contribution to health perception in a population of middle-aged male employees. The results revealed that physical activity was the only lifestyle factor which predicted good health perception. Further studies have corroborated the positive association between physical activity and health perception (Eurenius & Stenström, 2005; Kaleta, Makowiec-Dąbrowska, Dziankowska-Zaborszczyk, & Jegier, 2006; Pohjonen & Ranta, 2001).

Body Mass Index (BMI). BMI is a traditional index for body weight relative to height (kg/m^2 or lbs/inch^2). Based on the BMI, an individual's body weight can be categorized into underweight (BMI <18.5), normal weight (BMI 18.5-25), overweight (BMI 25-30), and obese (BMI \geq 30; World Health Organization, 2000).

Research has shown that high BMI is a serious risk factor for several diseases, such as coronary heart disease (Bogers et al., 2007), different types of cancer (Renahan, Tyson, Egger, Heller, & Zwahlen, 2008), and depression (Luppino et al., 2010). Seen from an economic perspective, high BMI entails increased costs for employers (Finkelstein, DiBonaventura, Burgess, & Hale, 2010). As van Nuys et al. (2014) pointed out, employers' costs rise when BMI exceeds 25. While a normal weight employee causes costs about \$3,830 per year, an obese employee costs the employer more than twice that amount, \$8,067. This expenditure is mainly due to absenteeism, health care costs and loss of productivity (Finkelstein et al., 2010; van Nuys et al., 2014).

Since past research has shown that inactivity is a major risk factor for high BMI or associated diseases (e.g., obesity; Mummery, Schofield, Steele, Eakin, & Brown, 2005; Vandelanotte, Sugiyama, Gardiner, & Owen, 2009), it follows that physical activity is conducive to BMI reduction. Empirically this association has been confirmed by several studies (Goodpaster et al., 2010; Koepp et al., 2013; Morgan et al., 2011). With regard to

workplace intervention research, Anderson et al. (2009) found by reviewing 15 studies that a workplace intervention involving physical activity and nutrition could decrease employees' weight and BMI. At six and twelve months after the intervention employees showed a weight reduction of 1.3 kg on average. Consequently, the intervention reduced employee BMI by 0.5 points. More recent studies corroborate the beneficial effect of physical activity interventions on employees' BMI (Burn, Heather Norton, Drummond, & Ian Norton, 2017; Viester, Verhagen, Bongers, & van der Beek, 2017). For instance, Reed et al. (2017) conducted a meta-analysis concentrating on working-aged women in high-income countries. They showed that workplace physical activity interventions reduced employees' BMI by 0.35 points. Nevertheless, Tam and Yeung (2018) state that there is still a high need for high quality intervention studies. Moreover, they suggest that physical activity interventions should include a motivational component, since these studies were most effective. These results led to the assumption that an intervention promoting physical activity in a work setting, while rising employees motivation and awareness for behavior change through a cognitive approach, is beneficial for employees' health perception and BMI. Based on the results of previous studies, we therefore assume:

Hypothesis 3: Employees in the intervention group show higher levels of health perception after the intervention than employees in the control group.

Hypothesis 4: Employees in the intervention group show a lower BMI after the intervention than employees in the control group.

Activity Trackers in Intervention Research

To date only a few studies have used activity trackers for health interventions. Nevertheless, there is sound evidence of the effectiveness of pedometers, which can be seen as a predecessor of activity trackers (i.e., simply tracks steps, no further health related data). For instance, Bravata et al. (2007) in a review of 26 studies showed that participants using pedometers increased their physical activity by 26.9% in comparison to their baseline physical

activity. More recent studies have elaborated on these findings by including modern activity trackers in interventions (Choi, Lee, Vittinghoff, & Fukuoka, 2016; Wang et al., 2015). Cadmus-Bertram, Marcus, Patterson, Parker, and Morey (2015) assigned 51 overweight women to two different intervention groups. The activity tracker group each received a Fitbit activity tracker while the participants in the other group each received a pedometer. The results showed that the activity tracker group increased their physical activity whereas the pedometer group showed no significant increase in physical activity. Despite this initial evidence on physical activity, there are only a few studies showing that using an activity tracker improves health (Abrantes et al., 2017; Lunney, Cunningham, & Eastin, 2016; O'Brien, Troutman-Jordan, Hathaway, Armstrong, & Moore, 2015; Wilson, Ramsay, & Young, 2017). So far only one study has investigated the effect of activity trackers on health in a work setting (Finkelstein et al., 2016). Employees from 13 companies were assigned to one control group and three intervention groups, all of whom received an activity tracker. The results showed that all intervention conditions increased employees' physical activity. Nevertheless, no changes in weight or other health related outcomes were found, possibly because the participants had better health conditions than the average worker. Moreover, it may be that in addition to an activity tracker, a cognitive approach is necessary to raise employees' awareness to bring about change in health behavior.

Our Physical Activity Intervention and Study Design

Intervention. To enhance employees' physical activity, we integrated a behavioral and a cognitive intervention approach. At the beginning of the intervention, participants were provided with the Garmin Vivofit 3 activity tracker, which constitutes the behavioral approach of the intervention. The Vivofit 3 is a wristband which registers daily steps or energy consumption. A summary of this information can be monitored on the activity tracker itself or in more detail on the Garmin Connect App. According to Shuger et al. (2011), this type of self-monitoring is a key aspect of how activity trackers affect health. Besides the

opportunity to gain information about one's own activity, the Vivofit 3 provides a reminder function, to encourage participants to become physically active after an hour of inactivity. We would like to note at this point that the activity tracker was only used as an intervention approach and did not serve to measure physical activity for a data collection purpose.

To raise employees' awareness and motivate them for a behavior change, an online coach was implemented, which constitutes the cognitive approach of the intervention. The online coach was a website from which participants could retrieve advice on how to increase their physical activity. In total four pieces of advice were offered over the course of three weeks, and these were based on recent studies or approved methods of behavior change (e.g., Bauman et al., 2012; Biagini et al., 2012; Heath et al., 2012; Sniehotta, Schwarzer, Scholz, & Schüz, 2005; Ziegelmann, Lippke, & Schwarzer, 2006). As the first piece of advice, participants were offered a tool for goal setting. Several studies have shown that generating action plans benefits behavior change (Luszczynska, 2006; Wiedemann, Lippke, Reuter, Ziegelmann, & Schüz, 2011; Williams & French, 2011). We therefore asked participants to set an individual health behavior goal. As a second step they were required to generate a plan on how they could achieve their individual goals. Further advice on physical activity was given twice a week (Monday and Friday) and aimed to support the participants in achieving their health behavior goals. For instance, the online coach informed participants about the benefits of coping plans in physical activity (Wiedemann et al., 2011; Ziegelmann et al., 2006). Coping planning is an approved method of health behavior change, where individuals are required to indicate internal and external barriers which inhibit them from achieving the desired health behavior (Sniehotta et al., 2005; Wiedemann et al., 2011). An example for a coping plan could be: "If it rains and I want to go out for a run, I will go to the gym instead." By linking anticipated risk situations to suitable coping responses, coping plans facilitate participants to act on their intentions (Sniehotta et al., 2005). Thus, coping plans are important

for the maintenance of a desired health behavior such as physical activity (Ziegelmann et al., 2006).

In the second week of the intervention, we conducted a step challenge as a gamification element to increase participants' motivation and pleasure at being physically active (Cugelman, 2013; Hamari, Koivisto, & Sarsa, 2014; Lin, Mamykina, Lindtner, Delajoux, & Strub, 2006). The term gamification refers to the process of including game design elements (e.g. challenges) into non-game context to invoke a gameful experience (e.g. enjoyment) while performing non-game related activities (Groh, 2012; Huotari & Hamari, 2012). The step challenge took four days in total. During this period participants were required to walk more than 40,000 steps, which, according to current research, is a reasonable target for healthy adults (Schneider, Bassett, Thompson, Pronk, & Bielak, 2006; Tudor-Locke et al., 2011). If this goal was achieved by at least 50% of the participants a reward was given for winning the challenge. Subsequently to the step challenge, the online coach supported the participants with two more pieces of advice to enhance their physical activity in the last week of the intervention. On average the online coach was visited 11.5 times per participant over the course of the intervention. This illustrates that on average every time new information (e.g. advice) was uploaded to the online coach participants visited the website.

Study design. The effectiveness of the intervention was examined using an RCT design over a three-week period. Due to requirements of the enterprise from which participants were recruited, the control group (CG) had to engage in intervention activities immediately after completion of the intervention group (IG). Therefore, we only had access to the IG to assess long term effects. Thus, measurements at five points were collected for the IG to evaluate the sustainability of intervention effects. Before the intervention group engaged in the intervention activities, IG and CG completed a pre-questionnaire (Time 1 [T1]; $n = 116$; 95.9%). After finishing the intervention, IG and CG answered a post-questionnaire (Time 2 [T2]; $n = 105$; 86.8%). Three more follow-up questionnaires distributed to the IG one month

after the intervention (Time 3 [T3]; IG: $n = 47$; 78.3%), three months after the intervention (Time 4 [T4]; IG: $n = 35$; 58.3%), and one year after the intervention (Time 5 [T5]; IG: $n = 35$; 58.3%). Before starting data collection, the study design was approved by the work council and the data protection officer of the enterprise from which participants were recruited. The work council is a committee which is responsible for representing the interest of the employees. Thus, we guaranteed the work council and the data protection officer that confidentiality was given at any time of the study and that the data do not permit conclusions on the individual level.

Materials and Methods

Sample

To evaluate the effectiveness of the intervention we recruited employees in one large enterprise in Germany between December 2016 and January 2017. The enterprise belonged to the mobility industry focusing on the transportation of freight and passengers. During recruitment the focus was explicitly on physically inactive employees at risk, who wanted to improve their health behavior. By means of posters, flyers, and an e-mail sent by the executive, employees' attention was drawn to a website offering information about the study (e.g. information about data security) and the opportunity to register for participation. Participation was voluntary and free of charge (including the use of the activity tracker), but employees had to be aged 18 or older and were not medically required to be on a diet or activity plan. In total 121 employees were enlisted as participants and were randomly assigned to the IG ($n = 60$) or the waitlist CG ($n = 61$). At the beginning of the study both groups received an invitation to complete the pre-questionnaire (T1). Participants who did not complete the first questionnaire were excluded from further analysis. Therefore the final sample consisted of 116 employees (IG: $n = 59$; CG: $n = 57$). In the final sample the age ranged from 19 to 62 years ($M = 43.01$; $SD = 12.72$), and 45.7% were female. The majority had acquired vocational training and worked full-time (86.1%). Since we focused on

physically inactive employees at risk during the recruiting procedure, employees worked in rather sedentary jobs. Moreover, 68.1% of the employees in the sample were classified as overweight or obese (BMI: $M = 27.21$, $SD = 4.74$).

Because only a very small number of employees dropped out due to not answering any further questionnaire after T1 ($n = 4$; 3.45%), we could not conduct a dropout analysis. However, we conducted a randomization check, testing whether the IG and CG differed in relation to sociodemographic variables and study variables at baseline (T1). No significant difference in sociodemographic variables and study variables were found.

Measures

The five questionnaires (T1-T5) were assessed online and included all study variables at each point of measurement. To match the questionnaires, participants were requested to create a personal code at the beginning of each questionnaire.

Physical Activity. Physical activity was measured with a modified version of the Godin Leisure-Time Exercise Questionnaires (GLTEQ; Godin & Shephard, 1985). Participants were asked how many times per week they had engaged in moderate and strenuous physical activity during the last month. Moderate physical activity was defined as not exhausting activities with a light perspiration (e.g., fast walking, gentle bicycling, badminton). Strenuous physical activity included activities such as running, vigorous long-distance cycling or football, where the heart beats rapidly and the perspiration is intense. To calculate a total score of weekly moderate to vigorous physical activity (MVPA), answers were converted to their metabolic equivalent. Metabolic equivalent (MET) expresses the energy expenditure as a result of being physical active (Byrne, Hills, Hunter, Weinsier, & Schutz, 2005). According to the different categories of physical activity, we multiplied the frequency of moderate physical activity by five MET and the frequency of strenuous physical activity by nine MET (Godin, 2011). The products of the various categories were then summed up into a total weekly MVPA score. For instance, for an employee who cycled to

work four times a week (moderate physical activity) and played football twice a week (vigorous physical activity), the total MVPA would be calculated in the following way:

$$\underbrace{(4 \text{ times cycling to work} \times 5 \text{ MET})}_{\text{moderate physical activity}} + \underbrace{(2 \text{ times football} \times 9 \text{ MET})}_{\text{vigorous physical activity}} = \underline{38 \text{ MVPA}}$$

Outliers were truncated to seven sessions of activity per week based on the assumption that most people engage in both moderate and strenuous activity only once per day.

Accordingly the total MVPA score ranged from 0 to 98 MVPA (7 sessions x 5 MET + 7 sessions x 9 MET) per week. The GLTEQ yields a retest reliability at one month of .62 for the total MVPA score (Sallis & Saelens, 2000). Moreover, the GLTEQ has been validated with physiological measures such as body fat and maximum oxygen intake (Amireault & Godin, 2015; Godin & Shephard, 1985).

Burnout. We assessed participants' burnout with the German version of the Shirom-Melamed Burnout Measure (SMBM; Shirom & Melamed, 2006). The SMBM consists of 14 items divided into three subscales: physical fatigue (e.g., "I feel physically drained"), cognitive weariness (e.g., "I have difficulty concentrating"), and emotional exhaustion (e.g., "I feel I am unable to be sensitive to the needs of coworkers and customers"). Participants were asked how often they had experienced these feelings at work during the last three weeks. Response alternatives were given on a scale from 1 (*Never or almost never*) to 7 (*Always or almost always*). Based on the participants' ratings, a global burnout score was calculated by aggregating the three different subscales.

Vigor. To assess vigor we used the 3-item-subscale taken from the German Version of the Utrecht Work Engagement Scale (UWES; Sautier et al., 2015; Schaufeli et al., 2006). A sample item reads: "When I get up in the morning, I feel like going to work". Participants could rate their individual vigor on a scale ranging from 1 (*never*) to 7 (*always/ everyday*).

The results of the reliability analysis for burnout and vigor are presented in Table 1 and show good internal consistencies at all measurement points. We conducted a confirmatory

Table 1

Zero-Order Correlations and Reliability of Study Variables

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Burnout T1	(.93)																			
2. Burnout T2	.77**	(.96)																		
3. Burnout T3	.79**	.85**	(.95)																	
4. Burnout T4	.71**	.84**	.83**	(.97)																
5. Burnout T5	.72**	.60**	.65**	.50**	(.98)															
6. Vigor T1	-.61**	-.66**	-.58**	-.44**	-.44**	(.90)														
7. Vigor T2	-.53**	-.69**	-.63**	-.48**	-.44**	.84**	(.91)													
8. Vigor T3	-.61**	-.72**	-.66**	-.64**	-.62**	.84**	.91**	(.95)												
9. Vigor T4	-.60**	-.71**	-.77**	-.62**	-.46**	.78**	.80**	.86**	(.94)											
10. Vigor T5	-.62**	-.54**	-.64**	-.43**	-.70**	.70**	.63**	.76**	.56**	(.95)										
11. Health Perception T1	-.33**	-.31**	-.32**	-.27*	-.25*	.28**	.28**	.18	.16	.25*	-									
12. Health Perception T2	-.35**	-.34**	-.34**	-.23*	-.33**	.28**	.32**	.24*	.14	.49**	.69**	-								
13. Health Perception T3	-.20	-.23	-.15	-.29	-.34	.13	.28	.08	-.05	.35*	.71**	.73**	-							
14. Health Perception T4	-.38*	-.40*	-.46**	-.48**	-.49**	.42*	.40*	.33	.50**	.42**	.31	.35*	.57**	-						
15. Health Perception T5	-.00	-.03	-.05	-.11	-.22	.20	.18	.09	-.14	.33	.39*	.32	.62**	.24	-					
16. BMI T1	-.06	.05	-.02	.06	.04	-.06	-.07	-.01	.05	.00	-.24**	-.30**	-.24*	-.06	-.24*	-				
17. BMI T2	.03	.07	.03	.09	.05	-.12	-.08	-.05	-.02	-.11	-.20	-.27**	-.20	-.08	-.19	.99**	-			
18. BMI T3	-.11	.06	-.02	.09	-.06	-.08	-.17	.01	.00	.00	-.28	-.17	-.28	-.14	-.34*	.99**	.99**	-		
19. BMI T4	-.00	.07	-.00	.12	.01	-.08	-.03	.04	.07	.00	-.26	.16	-.17	-.06	-.13	.98**	.98**	.98**	-	
20. BMI T5	-.07	.02	-.05	.12	-.03	-.08	-.13	.01	.18	-.00	-.35*	-.30	-.31	.05	-.35*	.97**	.98**	.97**	.98**	-

Note. T1 = Time 1; T2 = Time 2; T3 = Time 3; T4 = Time 4; T5 = Time 5; BMI = body mass index.

Correlations involving T3, T4, and T5 only include participants of the intervention group (n : follow-up I = 47, follow-up II = 35, follow-up III = 35).

* $p < .05$. ** $p < .01$.

factor analysis (CFA) including burnout and vigor measured at T1 using MPLUS 8.

Concerning the two-factor model with correlated but independent factors, the confirmatory factor analysis (CFA) revealed an acceptable fit for burnout (respecting the subscale structure) and vigor: $\chi^2(115, N = 116) = 227.64$, $p = .000$; comparative fit index (CFI) = .92; root mean square error of approximation (RMSEA) = .09; standardized root mean square residual (SRMR) = .09.

General Health Perception. General health perception was measured with a single-item of the Short-Form-36 Health Survey (Bullinger, 1995; Ware & Sherbourne, 1992). Participants were requested to indicate on a scale from 1 (*excellent*) to 5 (*poor*) how they perceive their health in general. The reliability and validity of this single-item measure has been confirmed by DeSalvo et al. (2006).

Body Mass Index (BMI). To assess participants' BMI we asked participants for information about their weight in kilograms ("How much do you weight?") and their height in centimeters ("What is your height?"). To calculate BMI we divided the weight of each participant by their height in meters squared (kg/m^2).

Time pressure. Besides the dependent variables we assessed time pressure as a control variable at T1. Time pressure was measured by using the subscale of the German Instrument for Stress-Oriented Task Analysis (ISTA; Semmer et al., 1995, 1999). In total the subscale consisted of four items, which can be rated on a scale reaching from 1 (very seldom/never), to 5 (very often). An examples item said: "How often are you under time pressure?". Cronbach's alpha for time pressure was .73 within our sample.

Statistical Analysis

Analyses were conducted using IBM SPSS Statistics 24. First, the data was tested for normal distribution as a requirement for applying repeated analyses of variance. The Sharipov-Wilk test did not show normal distribution for all study variables, therefore non-

parametric tests were performed additionally. However, the results remained qualitatively unchanged for all analyses.

Intervention effects were tested with repeated analyses of variance (ANOVA) comparing the intervention with control condition between T1-T2 with $\alpha = .05$ as a criterion for significance. For the investigation of long-term effects ANOVAs for repeated measures were conducted with the IG only. Additionally, a manipulation check was conducted by using a repeated analysis of covariance (ANCOVA), investigating the effect of the intervention on physical activity by controlling for time pressure.

Partial eta-squared (η_p^2) was used to interpret the relevance of the effects. A small effect is taken to be $\eta_p^2 \geq .01$, a medium effect, $\eta_p^2 \geq .06$, and a large effect $\eta_p^2 \geq .14$ (Cohen, 1988).

Results

Before testing for intervention effects, we conducted a manipulation check to test whether the IG showed a higher level of physical activity after completing the intervention. An ANCOVA for repeated measures revealed a significant interaction effect of group by time after controlling for time pressure at T1, $F(1, 102) = 4.20, p = .043, \eta_p^2 = .04$. Thus, the ANCOVA confirmed that the IG showed increased physical activity after the intervention compared to the CG (See Table 2), which indicates that the intervention was effective in increasing employees' physical activity. The covariate, time pressure, was not significantly related to employees' physical activity, $F(1, 102) = 0.61, p = .801, \eta_p^2 = .00$. Additionally to the manipulation check, we conducted a post-hoc analysis testing baseline by treatment effects, namely whether employees in the IG which were inactive at T1 benefited more from the intervention than active employees. Therefore, a median split ($Mdn = 14$) was used with the physical activity data at T1 creating a group of inactive employees ($n = 29$) and a group of active employees ($n = 28$). The ANOVA for repeated measures could find a significant interaction of group by time, $F(1, 45) = 4.47, p = .040, \eta_p^2 = .09$. Inactive employees

benefited significantly more from the intervention than employees which were already active at T1. Nevertheless, the analysis still revealed a significant main effect showing that both groups increase their physical activity from T1 to T2, $F(1, 45) = 5.53, p = .023, \eta_p^2 = .11$.

As a second manipulation check, participants were asked if they were still using the activity tracker three months and one year after the intervention and 84.2% of them reported that they were still using the activity tracker three months after the intervention. One year after the intervention, 74.3% of the participants were still using their activity trackers. Zero-order correlations between all study variables for all times of measurements are shown in Table 1.

Intervention Effects on Work-Related Well-Being

Intervention Effects on Burnout. Our first hypothesis proposed that the employees engaging in the intervention activities show a lower level of burnout than employees not performing the intervention. To test this assumption, we conducted an ANOVA for repeated measures between T1-T2. The results showed no significant interaction effect for group by time, $F(1,103) = .57, p = .452, \eta_p^2 = .01$ (see Figure 1a). Thus, hypothesis 1 was not supported.

We tested for long-term effects within the IG one month, three months, and one year after the intervention (see Figure 1b). One month after the intervention participants showed a significant reduction in burnout compared to burnout at baseline (see Table 2). The ANOVA for repeated measures between T1-T3 revealed a significant effect on burnout with a medium effect size, $F(1,46) = 5.10, p = .029, \eta_p^2 = .10$. No significant effect could be found three months (T1-T4) after the intervention, $F(1,34) = .05, p = .82, \eta_p^2 = .00$ or one year after the intervention, $F(1,34) = 1.47, p = .234, \eta_p^2 = .04$. In summary, we found a significant reduction in burnout level one month after the intervention, but this effect did not persist three months and one year after the intervention.

Table 2

Means and Standard Deviation for Study Variables at All Points of Measurement for Intervention and Control group

Variable	Group	<i>M (SD)</i>				
		Pre (T1)	Post (T2)	Follow-up I (T3)	Follow-up II (T4)	Follow-up III (T5)
Physical activity (MVPA)	IG	18.98 (16.36)	24.86 (21.91)			
	CG	20.05 (16.91)	19.89 (16.45)			
Burnout	IG	2.75 (.94)	2.57 (1.11)	2.47 (1.03)	2.60 (1.26)	2.45 (1.18)
	CG	3.01 (.97)	3.05 (1.12)	-	-	-
Vigor	IG	4.77 (1.19)	4.72 (1.33)	4.67 (1.34)	4.77 (1.23)	4.89 (1.22)
	CG	4.43 (1.19)	4.20 (1.16)	-	-	-
Health Perception	IG	3.56 (.75)	3.87 (.82)	3.85 (.71)	3.94 (.73)	3.83 (.75)
	CG	3.51 (.83)	3.53 (.83)	-	-	-
Body Mass Index (BMI)	IG	26.95 (4.55)	26.77 (4.63)	26.77 (4.68)	26.50 (4.71)	26.87 (4.89)
	CG	27.48 (4.94)	27.53 (4.91)	-	-	-

Note. *n* (IG): pre = 59, post = 48, follow-up I = 47, follow-up II = 35, follow-up III = 35; *n* (CG): pre = 57, post = 57.

IG = intervention group; CG = control group.

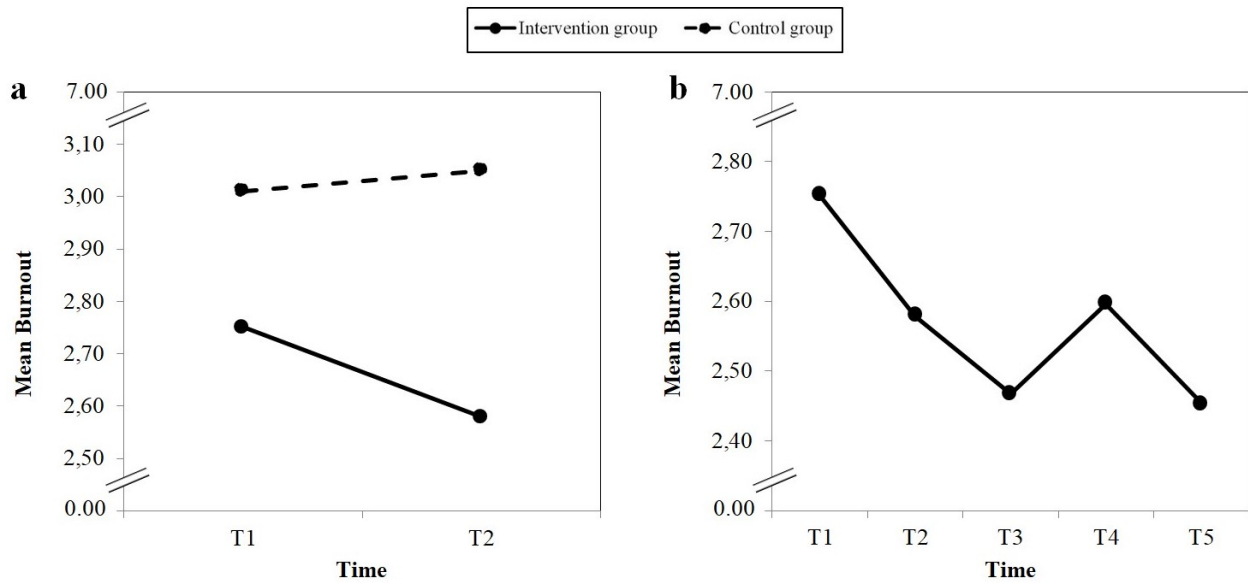


Figure 1a. Development of means for burnout for the IG and CG between T1 and T2.

Figure 1b. Development of means for burnout within the IG across T1, T2, T3, T4 and T5.

Note. IG = intervention group; CG = control group.

Intervention Effects on Vigor. To test the second hypothesis, stating that the intervention has a positive effect on vigor, we performed an ANOVA for repeated measures between T1-T2. The results revealed no significant interaction effect for group by time, $F(1,103) = .74$, $p = .391$, $\eta_p^2 = .01$ (see Figure 2a). Hence, hypothesis 2 was not supported.

Long-term effects were tested by conducting an ANOVA for repeated measures within the IG between T1-T3, T1-T4, and T1-T5 (see Figure 2b). No significant intervention effect could be found one month after the intervention (T1-T3), $F(1,46) = 1.43$, $p = .237$, $\eta_p^2 = .03$, three months after the intervention, $F(1,34) = 2.02$, $p = .165$, $\eta_p^2 = .06$, and one year after the intervention, $F(1,34) = 1.86$, $p = .181$, $\eta_p^2 = .05$.

Intervention Effects on Physical Health

Intervention Effects on Health Perception. As proposed in hypothesis 3, we expected that employees engaging in intervention activities show higher levels of health perception. An ANOVA for repeated measures revealed a significant interaction effect for group by time with a small effect size, $F(1,103) = 4.93$, $p = .029$, $\eta_p^2 = .05$ (see Figure 3a). The IG showed

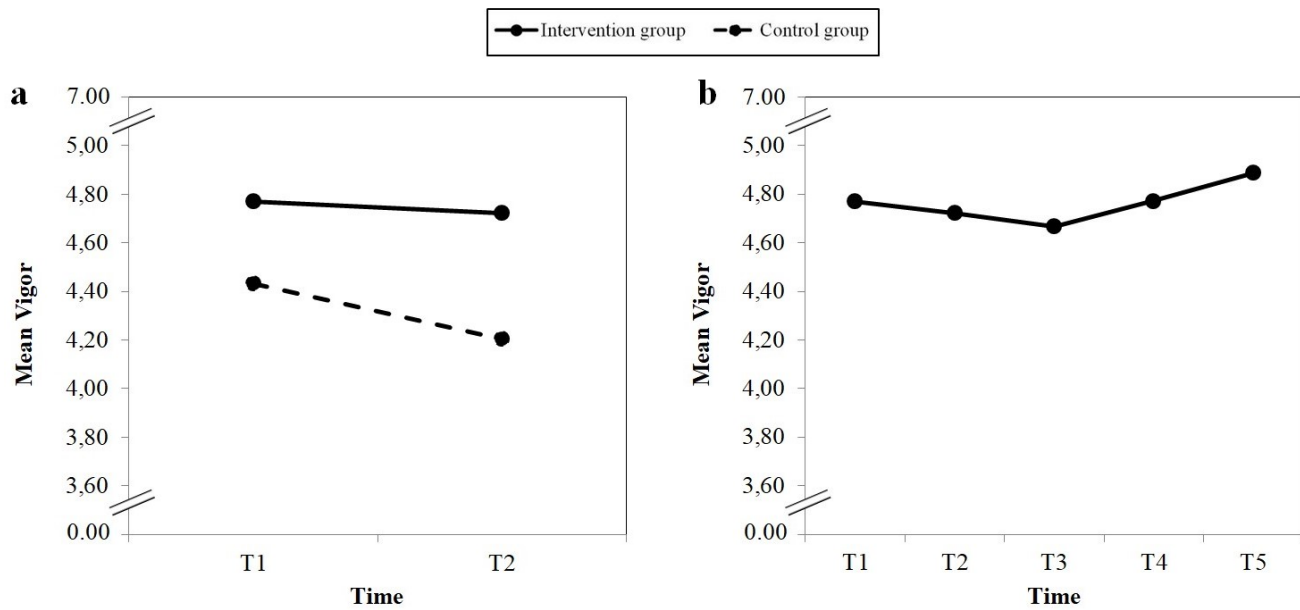


Figure 2a. Development of means for vigor for the IG and CG between T1 and T2.

Figure 2b. Development of means for vigor within the IG across T1, T2, T3, T4 and T5.

Note. IG = intervention group; CG = control group.

significantly higher means in health perception after the intervention period (See Table 2).

Thus hypothesis 3 was supported.

To test whether the intervention effect was persistent over time, an ANOVA for repeated measures between T1-T3 was conducted with the IG. It showed that a significant intervention effect on health perception still persisted one month after the intervention revealing a large effect size, $F(1,47) = 9.40, p = .004, \eta_p^2 = .17$. Further long-term effects were tested three months (T1-T4) and one year (T1-T5) after the intervention. Three months after the intervention the IG showed significant higher means in health perception than before engaging in the intervention activities, $F(1,34) = 4.99, p = .032, \eta_p^2 = .13$. However, one year after the intervention the ANOVA for repeated measures revealed no significant intervention effect, $F(1,34) = 1.09, p = .304, \eta_p^2 = .03$. The significant increase in health perception within the IG is shown in Figure 3b.

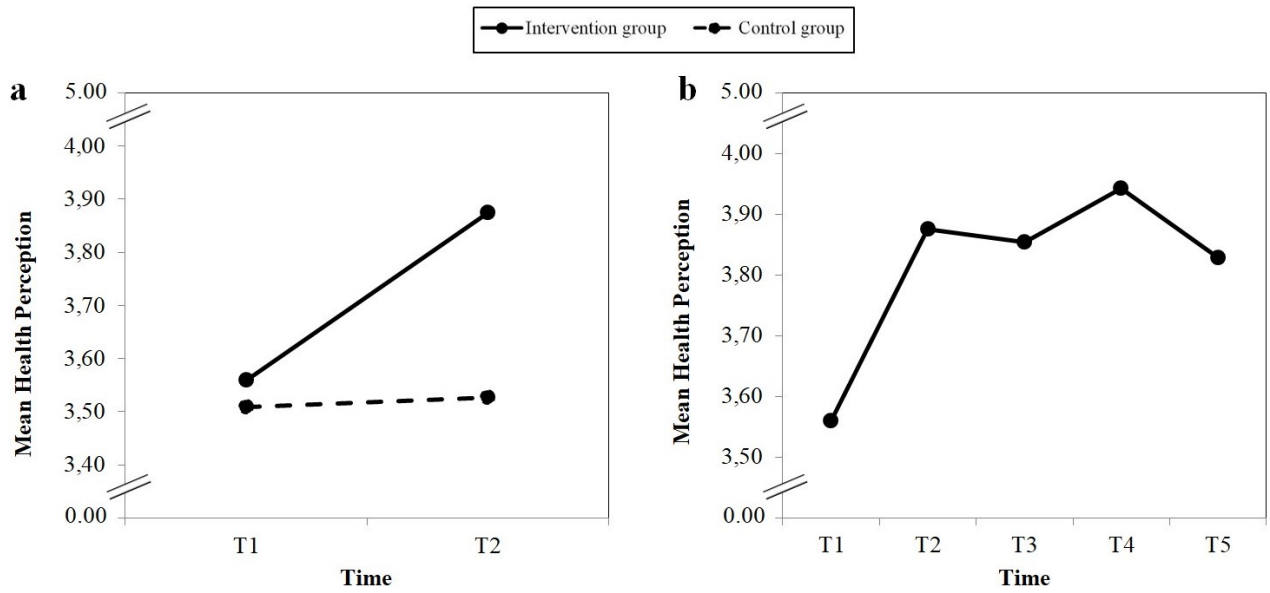


Figure 3a. Development of means for health perception for the IG and CG between T1 and T2.

Figure 3b. Development of means for health perception within the IG across T1, T2, T3, T4 and T5.

Note. IG = intervention group; CG = control group.

Intervention Effects on BMI. Our fourth hypothesis proposed that the intervention affects employees' BMI in the sense that employees in the IG have a lower BMI than employees in the CG. The ANOVA for repeated measures revealed a significant interaction effect for group by time between T1-T2 with a medium effect size, $F(1,103) = 9.07, p = .003, \eta_p^2 = .08$ (see Figure 4a). Hence, hypothesis 4 was supported.

We moreover tested if the intervention effect on BMI within the IG was long-lasting and therefore conducted an ANOVA for repeated measures between T1-T3. It showed that there was still a reduction of BMI with a large effect one month after the intervention, $F(1,47) = 13.77, p = .001, \eta_p^2 = .23$. Additionally, we tested for long-term effects three months after the intervention (T1-T4) and one year after the intervention (T1-T5). The ANOVA for repeated measures revealed a significant intervention effect with a large effect size three months after the intervention, $F(1,36) = 18.25, p = .000, \eta_p^2 = .34$. One year after the intervention the ANOVA for repeated measures between T1-T5 showed a significant intervention effect on BMI with a large effect size, $F(1,34) = 6.85, p = .013, \eta_p^2 = .17$.

Consequently, one year after the intervention, employees in the IG had a lower BMI than before engaging in the intervention activities (See Table 2). The significant reduction of mean in BMI overtime within the IG is illustrated in Figure 4b.

Discussion

The aim of this study was to examine the effect of a cost-effective new technology on physical activity as well as work-related well-being and physical health in a sample of employees at risk within one company. By combining a behavioral intervention approach using activity trackers and a cognitive intervention approach providing an online coach, we offered an attractive intervention tool which was still being used by most of the participants even one year after the intervention. With an RCT design and long-term follow-up analyses, we were able to show that high-risk employees benefited substantially from the intervention through an increase in health perception and a reduction of BMI.

Long-term analyses were conducted with the IG only and revealed that the intervention effect on health perception and BMI were persistent over time (3 months for health perception and one year for BMI). Contrary to our expectations we found no effect on work-related well-being. Interestingly, long-term analyses showed a significant reduction in burnout in the IG with a medium effect size one month after completion of the intervention. However, no further long-term effects on work-related well-being were found. Overall, the results demonstrate that the intervention did indeed improve employees' physical health, but had no impact on work-related well-being.

To the best of our knowledge, this is the first study to investigate the effectiveness of a combined cognitive-behavioral intervention using activity trackers. Due to their accessibility and availability (can be used anywhere, at any time; Borrelli & Ritterband, 2015), activity trackers combined with an online tool are an effective and economic way to improve employees' physical health. We discuss the findings in relation to work-related well-being (i.e., burnout and vigor) and physical health (i.e., health perception and BMI) below.

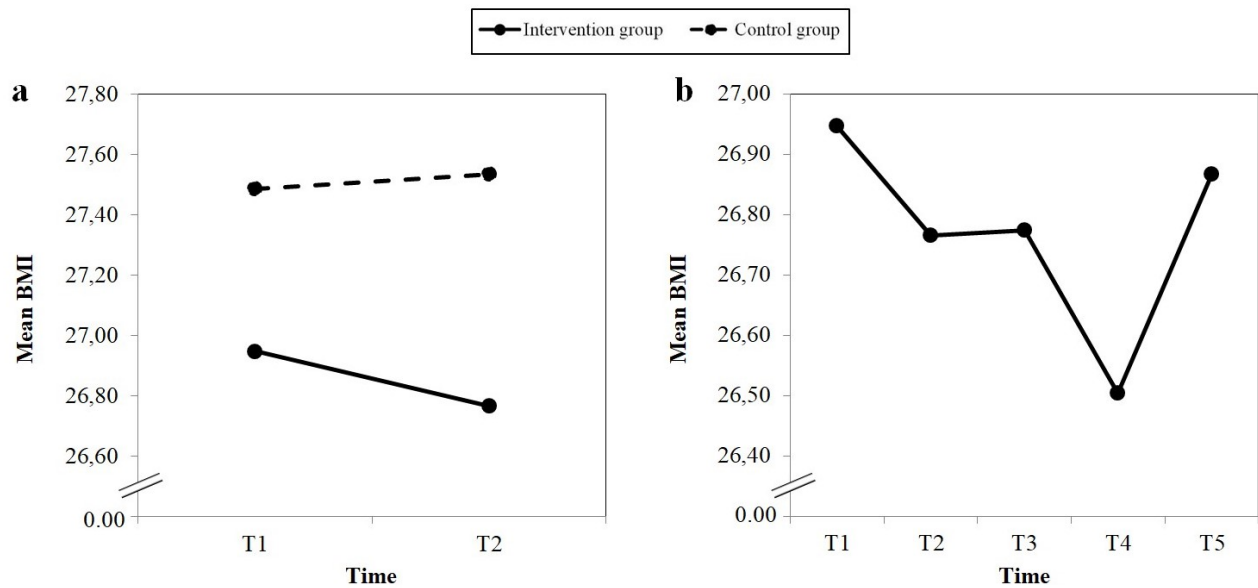


Figure 4a. Development of means for BMI for the IG and CG between T1 and T2.

Figure 4b. Development of means for BMI within the IG across T1, T2, T3, T4 and T5.

Note. IG = intervention group; CG = control group; BMI = body mass index.

Enhancing Work-Related Well-Being

Contrary to our hypotheses, we found no direct intervention effect on burnout and vigor. We found a delayed effect for burnout one month after the intervention in the IG. However, this effect was not maintained three weeks or one year after the intervention. Contrary to our findings, various studies have indeed reported significant associations between physical activity and burnout (Bretland & Thorsteinsson, 2015; Gerber et al., 2013; Naczenski et al., 2017; Tsai et al., 2013; van Rhenen et al., 2005). Given that our manipulation check showed an increase in physical activity, we would also have expected to see effects on burnout. The following explanations are possible:

In contrast to these studies, we aimed to reduce burnout by introducing activity trackers as a cost-effective intervention supported by an online coach. Most of the interventions capable of significantly reducing burnout have included face-to-face exercise sessions with a professional trainer (Bretland & Thorsteinsson, 2015; Gerber et al., 2013; Tsai et al., 2013; van Rhenen et al., 2005). One typical symptom of burnout is withdrawal from

social contacts and consequently the danger of isolation (Maslach & Pines, 1977). Face-to-face exercise sessions may possibly extenuate this symptom by linking the positive experience of being physically active (e.g., enjoyment) to social interaction. Moreover, meeting with a professional trainer may be experienced as social support, so that factors other than physical activity alone may have contributed to reduction in burnout. This assumption is supported by findings from Tsai et al. (2013), who showed that participants who attended exercise sessions led by a professional trainer experienced significantly reduced burnout whereas participants who had to plan and carry out exercises on their own showed no alleviation of burnout. Another study which reported a significant decrease in burnout included relaxation techniques in addition to physical activity exercises which possibly boost the positive effect of physical activity on burnout (van Rhenen et al., 2005). Since our intervention did not address these factors, this might also be the reason why we only found an intervention effect on burnout one month after the intervention. As Schaufeli, Maassen, Bakker, & Sixma (2011) postulated 72-77% of the variance in burnout is accounted to a change component influenced by several factors such as long working hours (Lim, Kim, Kim, Yang, & Lee, 2010) or social support (Adriaenssens, Gucht, & Maes, 2015; Halbesleben, 2006). It is possible that these factors fluctuate over the course of the study which might have caused the effect on burnout one month after the study. Apart from the intervention design involving no face-to-face interaction, the assessment of burnout which we used in our study may also have yielded different results. Contrary to many studies, we assessed all dimensions of burnout, whereas other studies have focused on subscales, primarily the emotional exhaustion subscale (Naczenski et al., 2017). Reducing burnout overall instead of its components is likely to be harder to achieve or may require different intervention approaches.

In relation to vigor we found no intervention effects. Here, the correlational studies are also more inconsistent: Some studies have reported a positive association between physical activity and vigor (e.g., ten Brummelhuis & Bakker, 2012), whereas other studies report no

such association (e.g., van Berkel et al., 2013). The only RCT-intervention study to report a positive effect of physical activity on employees' vigor consisted of a very small sample size (IG: $n = 24$; CG: $n = 10$; Pronk et al., 2012). The second RCT study on physical activity and employees' vigor found no overall effect of the intervention (Strijk et al., 2013). In this study only employees engaging intensively in physical activity (i.e., yoga workouts), felt significantly more vigorous after the intervention. First, the study by Strijk et al. (2013) may indicate that a large amount of physical activity is necessary to significantly increase vigor. Other components such as mental relaxation and mindfulness inherent in the practice of yoga accentuated the effect on vigor. We argued above that being physically active produces higher cortisol concentration (Anderson & Wideman, 2017), which in turn is associated with feeling more vigorous (Tops et al., 2006). However, González-Romá et al. (2006) pointed out that high intensity of physical activity is needed to raise cortisol concentration. It may be that, our intervention did not enhance the intensity of employees' physical activity sufficiently so as to increase cortisol concentration and in turn vigor. Charmas et al. (2009) corroborate this when showing that a one-hour aerobic session occasioned no increase in cortisol concentration. Van Berkel et al. (2013) moreover assume that they failed to find an association between vigor and physical activity because the employees did not perform enough physical activity. Because the rise of cortisol as a bodily response to physical activity occurs short term, it is also plausible that we found no intervention effect on vigor because no measurements were taken immediately after employees were physically active. It may be that the increase in physical activity caused by our intervention did indeed increase vigor, but that effect declined before the employees reported their vigor.

It may well be overall that physical activity affects work-related well-being less directly than other health outcomes. One option for more effective physical activity interventions could be to include components such as face-to-face sessions and mental relaxation to support the positive effect of physical activity on burnout and vigor. By

including such components in our intervention the slight effect of the intervention on burnout could likely be reinforced and vigor significantly enhanced.

Improving Physical Health

In line with our hypotheses, the intervention did effectively improve employees' health perceptions and reduce BMI. Additionally, we were able to show that the IG benefited from the intervention as evidenced a continuous improvement in health perception with a medium effect size up to three months after the intervention and a constant decrease in BMI with a large effect size up to one year after the intervention. Large effect sizes in workplace intervention research, especially with interventions involving no face-to-face interactions or multiple workshops over several months are rare and serve to underline the efficacy of this intervention.

Our results support the findings of various other intervention studies on physical activity that increased employees' health perceptions and lowered their BMI (e.g., Anderson et al., 2009; Bogaert et al., 2014; Okano et al., 2003; Reed et al., 2017). Interestingly, the only study to investigate the effect of an intervention with activity trackers on employees' health found no effects in relation to health outcomes (Finkelstein et al., 2016). These inconclusive results may be attributable to differences in intervention design. Finkelstein et al. (2016) offered employees a financial incentive in addition to the activity tracker when they walked a certain number of steps per week. The external reward offered by Finkelstein et al. (2016) rather enhances extrinsic motivation, whereas our intervention was intended to increase extrinsic and intrinsic motivation by enhancing enjoyment (e.g., the step challenge), competence for behavior change (advice from the online coach) or setting personal objectives (tool for goal setting; Ryan, Patrick, Deci, & Williams, 2008). It is well established that intrinsic motivation is more effective than extrinsic motivation with regard to promoting health behavior change and health, especially when aiming at long-term effects (Ng et al., 2012; Silva et al., 2010; Teixeira, Carraça, Markland, Silva, & Ryan, 2012). We therefore

believe that the combination of a cognitive and behavioral approach is effective and necessary to ensure strong effects over time.

Limitations and Future Research

In the following we will discuss the limitations of our study and provide suggestions for future research. First, 43.3% of the participants in the IG dropped out between the first and the last questionnaire one year later. Although, other eHealth studies investigating long-term effects have reported higher dropout-rates (e.g., Etter (2005): 64.3%; Eysenbach, 2005), in our study relatively small sample sizes resulted from the dropout for the long-term analyses (T4: $n = 35$; T5: $n = 35$) given that we started the study with a relatively small sample of 60 employees.

One major strength of our study was the use of an RCT design which enabled causal conclusions on the effectiveness of the intervention. We can firmly state that our results are not a cause of survey effects (Sitzmann & Wang, 2015) or a result of participating in a study (Hawthorne effect; Wickström & Bendix, 2000). Nevertheless, we only had access to the CG between T1-T2. Therefore, long-term effects could only be tested within the IG. However, since effects on behavior change as a result of participating in a study mainly occurs short-term, it is less probable that our long-term effects are skewed due to Hawthorne effects (McCambridge, Witton, & Elbourne, 2014). However, further studies should include a CG when testing for long-term effects to totally exclude possible survey effects. Also, future studies should include an alternative intervention to contrast different types of physical activity interventions.

Despite recruiting at a single mobility enterprise in Germany enabled us to collect data from a relatively homogenous population of employees at risk, the generalizability to other occupational sectors might be reduced. Thus, it could be possible that the intervention show different efficacy under different working conditions. For instance, employees which are required to work in a fixed body positions for a longer period of time (e.g. airplane pilots),

might be restricted to fulfill the intervention due to their low job control on how to carry out their job. Since it has been shown that low job control is associated with physical inactivity (Fransson et al., 2012) and a higher BMI (Berset, Semmer, Elfering, Jacobshagen, & Meier, 2011; Kottwitz, Grebner, Semmer, Tschan, & Elfering, 2014), future studies might consider the influence of job control when recruiting at specific occupational sector.

Another potential limitation of our study is that some measures may not have been sensitive enough to detect possible intervention effects. With regard to work-related well-being it is possible that the intervention would have shown an effect on a less extreme stress-syndrome than burnout. Burnout has been described as a syndrome which occurring after prolonged exposure to stress at work (Shirom et al., 2006). Therefore it would be interesting to investigate the effect of a cognitive-behavioral intervention with activity trackers on employees' stress levels using a more sensitive stress measure. Moreover, it might be possible that other work-related stressors could influence the effectiveness of the intervention. In our study we included time pressure as a stressor which, however, had no impact on employees' physical activity. Nevertheless, previous studies showed that other work-related stressors such as long working hours could diminish physical activity among employees (Kirk & Rhodes, 2011; Schneider & Becker, 2005; Wempe & Rosvall, 2005). Thus, future intervention studies including activity trackers should consider further potential work-related stressors when aiming to improve work-related well-being. Furthermore, our intervention may not have been effective enough to increase physical activity to a level that in turn boosts cortisol levels beyond a putative threshold that is needed to improve vigor.

Practical Implications and Conclusion

The results of our study show that activity trackers are a promising technology for workplace health promotion. In combination with an online coach as a cognitive approach, activity trackers are effective in improving physical health for employees at risk over time. Given that obese employees show a 22.6% higher work absence (Duijts et al., 2007) and that

a decrease of one BMI point will lower the costs for an obese employee by 3.7% (van Nuys et al., 2014), it is most likely that a cognitive-behavioral intervention with activity tracker could reduce employers' costs for absenteeism in the long-term. Moreover, activity trackers are not costly and therefore offer an interesting approach for companies to foster physical activity among employees. Also, the online coach can be developed and programmed to include considerable resources. Both approaches are extremely attractive as they offer brief interventions that can be conducted during and after working hours. Moreover, it is noteworthy that the majority of employees in the IG continued using the activity tracker after the intervention period. Three months after the intervention, 84.2% of the employees were still using their activity trackers and 74.3% of the employees were still using the activity tracker one year after the intervention. This suggests that employees enjoy using activity trackers and that these serve to motivate employees to engage perseveringly in health behavior. Along with the fact that our intervention yielded large effect sizes this seems to be a promising approach for employees at risk. We wish to note at this point that this intervention was strongly promoted by the human resources department of the enterprise. Employees received detailed information through email, flyers, and the project website. Also, the work council and the data protection officer were involved at all times and supported our study. Even though the intervention itself is quite feasible it involved a considerable amount of resources from the organizers and was well-integrated into the wider health promotion strategy of the company.

We need to acknowledge that apart from positive effects for physical health, this intervention approach was not effective in reducing burnout and promoting vigor. Other approaches such as mental relaxation, positive work reflection or mindfulness seem more promising for reducing burnout, emotional exhaustion, and increasing vigor (e.g., Clauss et al., 2018; Luken & Sammons, 2016; Steidle, Gonzalez-Morales, Hoppe, Michel, & O'Shea, 2017).

In conclusion, our study showed that a cognitive-behavioral intervention with activity trackers effectively improved employees' health perception and reduced BMI with a medium and a large effect size. These effects were sustainable over time. Three months after the intervention employees still perceived their health status to be superior to what it had been before the intervention. Regarding BMI, employees showed a significant decrease until one year after the intervention. We therefore conclude that our cognitive-behavioral intervention with activity trackers was effective in sustainably improving physical health for employees at risk.

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A step away from impaired well-being: a latent growth curve analysis of an intervention with activity trackers among employees

Thomas Lennefer, Dorota Reis, Elisa Lopper & Annekatrin Hoppe

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A step away from impaired well-being: a latent growth curve analysis of an intervention with activity trackers among employees

Thomas Lennefer^a, Dorota Reis^b, Elisa Lopper^a and Annkatrin Hoppe^a

^aDepartment of Psychology, Humboldt University of Berlin, 12489, Berlin, Germany; ^bSaarland University, Campus A2 4, Saarbrücken, Germany

ABSTRACT

The present study evaluated the effectiveness of a workplace intervention combining activity trackers (behavioural approach) with an online coach (cognitive approach) in order to increase employees' number of steps and improve their impaired well-being (i.e., emotional strain and negative affect). To analyse the intervention's effectiveness, the study applied latent growth curve modelling. Moreover, we tested whether work-related and personal resources (i.e., job control and self-efficacy) moderated the intervention's effectiveness and whether an increase in number of steps was associated with an improvement in impaired well-being. During the intervention, data were collected at six measurement points from 108 mainly low active employees. The results revealed that employees increased their number of steps until the second intervention week; this increase was not moderated by job control or self-efficacy. Moreover, the intervention was effective in decreasing emotional strain and negative affect over the course of the intervention. Further analyses showed that the increase in number of steps was related to the decrease in negative affect, whereas no such association was found for the increase in number of steps and the decrease in emotional strain. In conclusion, the findings showed that our intervention was effective in improving physical activity and impaired well-being among employees.

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Wearable activity trackers; employees' health; physical activity; eHealth; latent growth curve model (LGCM); workplace health promotion

Introduction


Activity trackers are small electronic devices that can be worn on an individual's body to collect and display health data, such as number of steps, with high validity (Evenson et al., 2015; Hoy, 2016; Huang et al., 2016; Ilhan & Henkel, 2014; Simunek et al., 2016). These devices have become increasingly prominent as a means of improving physical activity, which is defined as any bodily movement produced by skeletal muscles that results in energy expenditure (Caspersen et al., 1985). As previous research has shown, physical activity is positively related to organizational outcomes such as absenteeism and job satisfaction (Arslan et al., 2019; Fang et al., 2019; Grmani et al., 2019; Parks & Steelman, 2008; Virtanen et al., 2018). Moreover, physical activity affects several well-being outcomes (e.g., stress and negative affect; e.g., Bruin et al., 2017; Conn et al., 2009). Thus, promoting physical activity is desirable from the perspective of the employee as well as the employer.

Particularly, activity trackers seem to be an attractive technology for promoting physical activity due to their accessibility (can be used anywhere, at any time; Borrelli & Ritterband, 2015), which makes them easy to integrate into daily work routines. For this reason, we created a cognitive-behavioural intervention lasting three weeks in total, which aimed to increase physical activity and improve impaired well-being (i.e., emotional strain and negative affect) among employees. The intervention combined activity trackers (behavioural approach) which use common behavioural change techniques such as self-monitoring along with an online coach

(cognitive approach) offering advice on how to increase physical activity (e.g., goal setting and planning).

Overall, our study contributes to the existing literature in several ways. First, we tested the effectiveness of a promising technology within a theory-based intervention framework that has rarely been considered in the occupational health promotion context. Furthermore, possible moderators were considered to test whether intervention efficacy depended on work-related (i.e., job control) or personal resources (i.e., self-efficacy). Second, as we recruited at one large company in Germany, we were able to address a specific group of mainly low active employees, which is usually difficult to approach. Finally, data were collected twice a week (Mondays and Fridays) during the intervention, which results in a total of six points of measurement and enabled us to apply latent growth curve modelling (LGCM) to the data. LGCM is a powerful and modern method through which we received a detailed insight into the change of physical activity and impaired well-being during the intervention by modelling flexible growth trajectories (e.g., linear or curvilinear). Moreover, LGCM offers the opportunity to link the growth of one variable (e.g., employees' number of steps) to the growth of another variable (e.g., employees' emotional strain) providing information about the relationship between the variables. Even though LGCM yields new information for intervention research, only few physical activity intervention studies have reported using this technique, and none of them have implemented activity trackers within their interventions (McAuley et al., 1999; Motl et al., 2005; C. Pedersen et al., 2019; Roesch et al., 2010; Staiano et al.,

CONTACT Thomas Lennefer Email  thomas.lennefer@hu-berlin.de

 Supplemental data for this article can be accessed [here](#).

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2013). Hence, our study contributes theoretically and methodically to the existing literature of workplace physical activity intervention studies.

Theoretical background

Enhancing physical activity through activity trackers

Activity trackers are an interesting new technology offering different approaches for increasing motivation to become physically active such as self-monitoring and awareness for health behaviour change (e.g., feedback or gamification elements; Shih et al., 2015; Shuger et al., 2011). Previous research has shown that intrinsic motivation is especially relevant for the maintenance of physical activity (Ryan et al., 1997; Teixeira et al., 2012). According to the Self-Determination Theory (SD-Theory; Ryan, 1982; Ryan & Deci, 2002), motivation is a continuum reaching from amotivation over controlled motivation to autonomous motivation which is the most pure form of intrinsic motivation and therefore most sustainable and desirable. Amotivation is on the one end of the continuum where individuals show no form of extrinsic or intrinsic motivation for certain behaviour (Deci & Ryan, 2008). Individuals who are controlled motivated either perform a behaviour to avoid guilt or obtain social approval or to avoid punishment or obtain a reward (Deci & Ryan, 2008). The most pure form of intrinsic motivation is autonomous motivation where individuals engage in certain behaviour due to experiencing pleasure, obtaining a personal goal, and valuing the outcome of the behaviour (Deci & Ryan, 2008). According to SD-Theory motivation is more autonomous when the three basic psychological needs (i.e., competence, autonomy, and relatedness) are satisfied (Deci et al., 2017; Deci & Ryan, 2000; Vallerand, 1997). Additionally, even extrinsic motives can become more autonomous through the internalization of these motives which is facilitated by meeting the three psychological needs (Ryan, 2009; Ryan & Deci, 2002). Various aspects of activity trackers address these needs. The desire to seek challenges optimally suited to one's capacity (competence; Ryan & Deci, 2002), could be fulfilled by activity trackers through offering a customized activity goal related the user's current activity level. Autonomy refers to the feeling of being the origin of one's own behaviour (Ryan & Deci, 2002), which could be addressed by activity trackers due to the option to individualize activity goals and the information displayed on the activity tracker. Finally, the ability to share achieved activity goals on social networks and to interact with the activity tracker's community could possibly satisfy the need to feel connected to other (relatedness; Ryan & Deci, 2002). Previous research showed that promoting these three basic psychological needs by the activity tracker leads to a higher motivation to use the activity tracker (Rupp et al., 2016, 2018). Thus, it is likely that activity trackers are effective in increasing physical activity by promoting the three basic psychological needs of SD-Theory.

Even though the use of activity trackers seems promising, they have rarely been included in workplace interventions to date. Nevertheless, studies applying activity trackers in other settings have yielded positive results regarding their effect on

physical activity. For instance, Cadmus-Bertram et al. (2015) assigned 51 overweight women to two different intervention groups. One group received an activity tracker whereas the other group received a pedometer, which can be seen as a predecessor to activity trackers (i.e., a device that simply tracks steps, providing no further health-related data). The results revealed that participants wearing an activity tracker increased their average number of steps by 789 steps per day, whereas the pedometer group showed no significant increase in number of steps. Further studies have confirmed the positive intervention effect of activity trackers on number of steps in different samples (Abrantes et al., 2017; Finkelstein et al., 2016; Wang et al., 2015). Nevertheless, two studies revealed that the increase in number of steps only occurred in the first weeks of the intervention (O'Brien et al., 2015; Wang et al., 2015). Thus, the increase in number of steps resulting from the use of activity trackers needs to be examined in more detail over an intervention period. Given the evidence set out earlier, we assume:

Hypothesis 1: During the course of the intervention, the number of steps increases.

Work-related and personal resources reinforcing the promotion of physical activity

Given that our intervention will be conducted in a work setting, it is likely that the intervention's efficacy is affected by employees' working conditions. Especially job control seems to be a relevant work-related resource since past research has shown that low job control is positively associated with physical inactivity (Fransson et al., 2012; Griep et al., 2015).

Job control can be defined as the extent to which an employee is able to influence his or her own working conditions, such as the pace of work or the order in which tasks are fulfilled (Semmer et al., 1995). As this definition implies, it is possible that high job control makes it easier for employees to integrate physical activity interventions into their daily work routine. Regarding this assumption, there is encouraging evidence from one qualitative study which evaluated the effectiveness of a treadmill workstation intervention (Cifuentes et al., 2015). Employees reported that they used the treadmill workstation more often if they were working in jobs with higher job control. Thus, it seems that job control is an important resource regarding worksite physical activity interventions.

An important personal resource for health behaviour change is self-efficacy which generally refers to the sense of control over one's environment and behaviour (Schwarzer & Luszczynska, 2007). However, Bandura (2010) proposed that domain-specific self-efficacy (e.g., for physical activity) is desirable when aiming to affect a certain behaviour. Thus, it is possible that employees who believe in their capability to increase their physical activity show a higher amount of physical activity than employees with low self-efficacy regarding physical activity. The Health Action Process Approach (HAPA) by Schwarzer (2008) suggests that self-efficacy is an important factor for different phases of increasing physical activity such as building the intention to become physically active or maintaining physical activity behaviour. Previous

research has shown that simply having the intention to become physically active does not sufficiently predict health behaviour change (Rhodes & Bruijn, 2013). According to the HAPA model, self-efficacy may help to bridge the gap between having the intention to become physically active and an actual increase in physical activity (Schwarzer, 2008).

Previous studies support the idea that self-efficacy is an essential factor for enhancing physical activity (Bauman et al., 2012; Prodaniuk et al., 2004; Stutts, 2002; Williams & French, 2011). Conducting a worksite physical activity intervention at two industrial production units, M. M. Pedersen et al. (2013) investigated whether employees with high self-efficacy showed higher intervention compliance than employees with low self-efficacy. The results revealed that employees with high self-efficacy regarding physical activity attended more exercise sessions. Nevertheless, this trend was significant in only one of the two companies. M. M. Pedersen et al. (2013) suggested that working conditions additionally may reinforce or diminish employees' compliance with workplace physical activity interventions. Given the theoretical and empirical evidence, we hypothesize:

Hypothesis 2: Employees having higher job control show a greater increase in number of steps during the intervention than employees with low job control.

Hypothesis 3: Employees having high self-efficacy show a greater increase in number of steps during the intervention than employees with low self-efficacy.

Reducing impaired well-being through physical activity

As indicators for impaired well-being, we used emotional strain and negative affect. Emotional strain is a construct that concentrates solely on the emotional aspect of occupational stress which is defined as an emotionally irritable reaction causing negative interactions between the social environment and the emotionally strained employee (G. Mohr, Müller et al., 2005). Thus, the state of emotional strain occurs if an employee intensely endeavours to achieve a certain goal, but the effort does not result in goal achievement. Due to goal discrepancy, a state of severe mental strain emerges, which can be seen as a direct precursor of depression (G. Mohr et al., 2006).

On the other hand, negative affect reflects the extent to which a person feels various aversive mood states such as anger and nervousness. High negative affect is characterized by a state of distress and unpleasant engagement, whereas people with low negative affect experience a state of calmness and serenity (Watson et al., 1988). Contrary to emotional strain, negative affect is a context-free construct not explicitly focusing on affect displayed within the work setting. Thus, emotional strain and negative affect differ in their relatedness to the work context (work-related vs. general).

We chose emotional strain and negative affect as indicators of impaired well-being since both constructs are related to important organizational outcomes. For instance, previous studies considering stress indicators (e.g., emotional strain) have shown that

employees experiencing stress perform more poorly in their jobs than do employees suffering less from stress (Bashir & Ramay, 2010; Hanif et al., 2011; Jamal, 2011). Moreover, Bowling et al. (2010) showed in a meta-analysis that absence of negative affect is associated with global job satisfaction as well as specific facets such as satisfaction with the work itself, satisfaction with co-workers, and satisfaction with pay. Thus, both constructs need to be addressed with effective interventions conducted at the workplace.

To decrease emotional strain (i.e., stress) and negative affect, promoting physical activity seems to be a promising intervention. According to the transient hypofrontality theory, physical activity is accompanied by an increase in the oxygen supply in the motor and sensory systems of the brain (Dietrich, 2003). Since the oxygen uptake during physical activity remains constant (Ide & Secher, 2000), areas in the prefrontal cortex responsible for cognition and emotions are inhibited. Thus, it is assumed that the diminished activity reduces negative thinking and negative emotional states (Dietrich, 2006; Dietrich & Sparling, 2004) so that consequently physical activity could decrease negative affect and emotional strain.

Previous studies have supported this assumption by showing a negative relationship between physical activity and impaired well-being (Bruin et al., 2017; Hansen et al., 2010; Jonsdottir et al., 2010; Lathia et al., 2017). For instance, Conn et al. (2009) conducted a meta-analysis concentrating on the effectiveness of workplace physical activity interventions to reduce stress. Considering approximately 38,231 subjects, they showed that physical activity effectively decreased job stress with a small effect size ($d = 0.33$). With regard to negative affect, a study by Abrantes et al. (2017) investigated the effect of activity trackers on negative affect in a sample of alcohol-dependent women. Twenty women received an activity tracker which was worn for 12 weeks during the intervention. The results revealed a significant decrease in negative affect whereas there was no significant effect found for positive affect. Based on this evidence, we therefore hypothesize:

Hypothesis 4: During the course of the intervention, employees' emotional strain decrease.

Hypothesis 5: The increase in number of steps is associated with the decrease in employees' emotional strain.

Hypothesis 6: During the course of the intervention, employees' negative affect decrease.

Hypothesis 7: The increase in number of steps is associated with the decrease in employees' negative affect.

Materials and methods

Intervention

The intervention conducted in this study aimed to improve employees' physical activity by combining a behavioural and a cognitive approach. The behavioural approach constituted the activity tracker (i.e., Garmin Vivofit 3). Employees received

the activity tracker a few days before the start of the intervention so that they had a chance to accustom themselves to the activity tracker and report possible technical issues. During the intervention, participants were required to wear the activity tracker on their wrist where it collected and monitored health information such as daily steps or energy consumption. Besides providing the health information displayed by the activity tracker, a more detailed summary was presented in the activity tracker's app (i.e., Garmin Connect app). As Shuger et al. (2011) showed, this type of self-monitoring plays a key role in how activity trackers affect health behaviour. In addition to the self-monitoring function, the selected activity tracker has a reminder function, which induces participants to become physically active after an hour of inactivity.

To further raise employees' awareness and motivation to change their behaviour, an online coach was implemented, which constituted the cognitive approach of the intervention. The online coach was a website which provided participants with advice on how to increase their physical activity twice a week (Monday and Friday) over the course of the three weeks of the intervention. Because Taylor et al. (2012) showed that worksite interventions premised on a theoretical foundation are more effective in increasing physical activity among employees, the pieces of advice given by the online coach were based on the HAPA model by Schwarzer (2008) or on current studies (e.g., Bauman et al., 2012; Biagini et al., 2012).

Thus, the first form of advice employees received was a tool for goal setting which required them to set their individual health behaviour goals. As a second step, we asked them to generate a plan as to how they could reach their individual goals. Since the HAPA model states that action planning is essential for intention building, and past research has shown that generating action plans benefits behaviour change (Luszczynska, 2006; Schwarzer, 2008; Wiedemann et al., 2011; Williams & French, 2011), we used this method to motivate employees to increase their physical activity. Further advice by the online coach aimed to support employees in reaching their individual health behaviour goals. For instance, the online coach informed participants about the beneficial effect of coping plans on physical activity (Wiedemann et al., 2011; Ziegelmann et al., 2006). Coping planning is a further method incorporated in the HAPA model (Schwarzer, 2008), which requires individuals to specify the internal and external barriers which prevent them from showing the desired health behaviour (Sniehotta, Schwarzer et al., 2005; Wiedemann et al., 2011). With regard to physical activity, an example of a coping plan could be: "If it is raining and I was planning to

go out for a run, I will go to the gym instead." In this example, an anticipated risk situation is linked to a suitable coping response, which helps participants to act according to their intentions (Sniehotta, Schwarzer et al., 2005). Thus, coping plans are important for maintaining a desired health behaviour such as physical activity (Ziegelmann et al., 2006).

Instead of providing advice on physical activity, we conducted a step challenge as a gamification element within the second intervention week of the intervention. The step challenge aimed to increase participants' autonomous and controlled motivation to become physically active by promoting enjoyment and offering a reward (Cugelman, 2013; Deci & Ryan, 2008; Goh & Razikin, 2015; Hamari et al., 2014; Lin et al., 2006; Shameli et al., 2017). It was announced on Monday of the second intervention week and took four days in total. Participants were required to walk more than 40,000 steps within four days, which is a reasonable target for healthy adults (Schneider et al., 2006; Tudor-Locke et al., 2011). A reward was provided for winning the challenge, which required at least 50% of the participants to reach the goal of more than 40,000 steps within the four days. Following the step challenge, the participants received two more pieces of advice on how to increase their physical activity in the last week of the intervention. For a visualization of the intervention procedure, please refer to Figure 1.

Sample and procedure

Before we started recruitment between December 2016 and January 2017, the study was approved by the works council and the data protection officer of the company from which the participants were recruited. Thus, we had to guarantee that confidentiality was given at all times and had to fulfil the data security requirements of the company. Recruitment was conducted within one large mobility company in Germany by using posters, flyers, and an email sent by the executive, which intended to draw employees' attention to a website offering information about the study and the opportunity to register for participation. By advertising the study, the focus was placed explicitly on inactive employees. However, due to the company's requirements, all employees aged 18 or older and not medically required to follow a diet or an activity plan, were eligible to participate. With regard to sample size, we followed the recommendation by Curran et al. (2010) stating that approximately 100 participants are sufficient for applying latent growth curve modelling. Since we expected that some employees would drop out during the study, we recruited

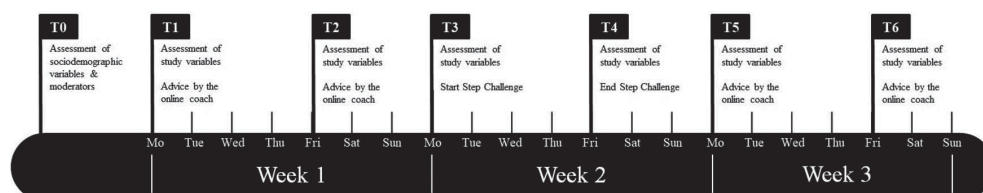


Figure 1. Overview of the intervention procedure and the points of measurements for sociodemographic variables and study variables.

Notes: T0 = 108; T1 = 92; T2 = 71; T3 = 94; T4 = 77; T5 = 93; T6 = 81. Abbreviations: T0, Time 0; T1, Time 1; T2, Time 2; T3, Time 3; T4, Time 4; T5, Time 5; T6, Time 6.

a greater number of individuals resulting in a total of 121 employees enlisted for study participation.

Before employees engaged in the intervention activities, we collected their sociodemographic variables and possible moderators (i.e., job control and self-efficacy) in a pre-questionnaire (T0). Next, the intervention was conducted in two waves to which employees were randomly assigned to. The first wave ($n = 60$) performed the intervention between January and February 2017, whereas the intervention activities of the second wave ($n = 61$) were started after the employees of the first wave had finished the intervention. To test whether the employees of the two waves differed regarding their sociodemographic variables, we conducted univariate analyses of variance and chi-square tests by using IBM SPSS Statistics 24. The results revealed no significant differences between the sociodemographic variables of the employees of the two waves.

Besides the pre-questionnaire (T0), six questionnaires (T1-T6) assessing the outcome variables (i.e., number of steps, emotional strain, and negative affect) were sent out to the participants on Monday and Friday in each of the three intervention weeks. A visual overview of the study procedure can be found in Figure 1. Employees who completed fewer than two questionnaires during the intervention (T1-T6) were excluded from further analyses so that the final sample consisted of 108 employees. Due to the small number of dropouts ($n = 13$; 10.74%), no attrition analysis could be conducted. Nevertheless, a comparison of the mean scores of the employees in the final sample and those of the dropouts revealed no major differences regarding their sociodemographic variables.

The employees in the final sample were predominantly male (55.6%), and the age ranged from 19 to 62 years ($M = 43.66$; $SD = 12.56$). The majority worked in full-time positions (88.0%) without shift duty (54.6%). Because our goal was to recruit inactive employees, most participants worked in sedentary jobs and showed a low number of steps per day. Thus, 62.0% of the employees in the final sample did not reach the recommended number of more than 10,000 steps per day (Tudor-Locke et al., 2011). Furthermore, 35.9% could even be classified as sedentary or low active according to their daily number of steps (<7,499 steps per day; Tudor-Locke et al., 2008; see Table 1).

Measures

The measures assessed during the intervention (T1-T6) are presented in the following together with the measures of possible moderators included in the pre-questionnaire (T0). At the beginning of each questionnaire, the participants were required to create their personal code to ensure that the different questionnaires they filled in could be matched.

Number of steps

To assess employees' daily number of steps the activity tracker's app (i.e., Garmin Connect app) was used. Due to the data security recruitments of the company from which employees were recruited, we were not allowed to take the number of steps registered by the activity trackers directly from the app. Therefore, employees were required to enter their daily

number of steps objectively taken from the app in the six questionnaires during the intervention (T1-T6). Since the number of steps might fluctuate between days, we decided to ask for the number of steps over the past three days to gain more detailed information about the employees' activity level. Thus, the employees reported their daily number of steps over the past three days in each of the six questionnaires. Subsequently, we then aggregated the step counts of the three reported days and calculated the average of number of steps for every measurement point.

Job control

To measure job control, we used the control subscale of the German Instrument for Stress-Oriented Task Analysis (ISTA; Semmer et al., 1995, 1999). The ISTA is a questionnaire focusing on the assessment of stress-related aspects of work. By focusing on the possibility of influencing one's own conditions, the control subscale assesses the decision latitude regarding the pace, the order or the ways in which a task is being carried out (Semmer et al., 1995). Hence, one example item is: "All together, how much possibility for own decision does your job contain?" Overall, the subscale consists of four items with a five-point response scale ranging from 1 (*very little*) to 5 (*very much*). Internal consistency for the job control scale was very good within our sample (Cronbach's $\alpha = .82$; DeVellis, 2016).

Self-efficacy

To measure self-efficacy, we used a scale specifically related to physical activity (Schwarzer & Luszczynska, 2007; Schwarzer et al., 2007). Based on the HAPA model by Schwarzer (2008), three items were considered, each explicitly focusing on one phase of self-efficacy postulated by the model. Thus, the item for task self-efficacy reads: "I am confident that I am able to be more physically active." Maintenance self-efficacy was assessed with the item: "I am confident to engage in physical activity regularly on a long-term basis, even if I find myself in situations, where this is difficult" and the recovery self-efficacy item reads: "I am confident that I am able to resume performing physical activity, even if I have not been physically active for several days." For each item response alternatives were given on a scale from 1 (*totally disagree*) to 4 (*totally agree*). Based on the participants' ratings, we calculated a global self-efficacy score by aggregating the three items and dividing them by three. The internal consistency for the self-efficacy scale was acceptable within our sample (Cronbach's $\alpha = .78$; DeVellis, 2016). Additionally, we conducted a confirmatory factor analysis (CFA) including job control and self-efficacy at T0 as two independent but correlated factors. The results showed a good fit for job control and self-efficacy: $\chi^2(103, N = 104) = 18.23$, $p = .149$; CFI = .97; RMSEA = .06; SRMR = .04.

Emotional strain

Emotional strain was measured six times during the intervention (T1-T6). To operationalize emotional strain, we used the five-item emotional irritation subscale of the German version of the Irritation Scale by G. Mohr, Rigotti et al. (2005). The Irritation Scale is a measure that specifically assesses strain in the occupational context. An example item of emotional irritation reads: "When I come home tired after work, I feel rather irritable." (G.

Table 1. Overview of the Sociodemographic Variables and the Activity Level.

Variables	Mean (Standard Deviation/%)
Age	43.66 (12.56)
Min	19
Max	62
Sex	
Female	44.4%
Male	56.6%
Fulltime Work	
Yes	12.0%
No	88.0%
Shift Duty	
Yes	45.4%
No	56.6%
Activity Level (acc. Tudor-Locke et al., 2008)	
Sedentary (<5,000 Steps per day)	9.8%
Low active (5,000–7,499 Steps per day)	26.1%
Somewhat active (7,500–9,999 Steps per day)	26.1%
Active (10,000–12,499 Steps per day)	22.8%
Highly active (>12,499 Steps per day)	15.2%

Mohr et al., 2006). On a scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*), participants rated their individual level of work-related emotional strain. Cronbach's alpha for emotional strain from T1-T6 is presented in Table 2.

Negative affect

Negative affect was measured by implementing the short-form of the positive and negative affect schedule (PANAS) at all six measuring points during the intervention (T1-T6; Krohne et al., 1996; Thompson, 2007; Watson et al., 1988). The participants received a list of five adjectives describing negative emotional states (e.g., upset) and were required to indicate how intensely they had experienced these states within the last two days. The response alternatives were given on a scale from 1 (*never*) to 5 (*always*). Cronbach's alpha for negative affect from T1-T6 is shown in Table 2. Besides the analyses of internal consistency, we conducted a CFA considering emotional strain and negative affect at T1. With regard to the two-factor model with correlated but independent factors, the CFA revealed a good fit for

emotional strain and negative affect: $\chi^2(90, N = 91) = 44.35, p = .110$; CFI = .95; RMSEA = .06; SRMR = .08.

Statistical analyses

To test the pattern of change proposed in our hypotheses, we used latent growth curve model (LGCM) within the structural equation modelling framework. LGCM is a flexible method for estimating inter-individual variability in intra-individual patterns of change over time (Curran et al., 2010). This involves modelling individual complex trajectories, which can be in a linear or a curvilinear form (Curran et al., 2010). In comparison to traditional methods such as analysis of variance (ANOVA), LGCM can be based on latent variables. By considering latent variables, LGCM renders patterns of change which are free of measurement errors (McArdle, 2009). Additionally, it is possible to consider measurement invariance over time about which traditional methods offer no information.

To test Hypotheses 5 and 7, we used parallel process growth modelling which is a specific form of LGCM which relates the slope of one variable to the slope of another variable so that it is possible to link the growth of one variable to the growth of another variable. Thus, using Mplus version 8 (Muthén & Muthén, 2017), we fitted a total of five latent growth curve models to the data, testing every hypothesis within a separate model. We tested all hypotheses in separate models because testing different hypotheses with one model would result in partial regression coefficients which were not described within our hypotheses. Only Hypotheses 4 and 5 and Hypotheses 6 and 7 were tested within one model, respectively, since these hypotheses included the same variables so that testing them within one model not produced partial regression coefficients. All hypotheses were tested with second-order LGCM using latent variables. For hypothesis 1 only, we used a first-order LGCM due to the manifest nature of the construct number of steps. Second-order LGCMs were computed by building item parcels and estimating strong measurement invariance. As an addition to LGCM, we used latent change score modelling (LCS)

Table 2. Zero-Order Correlations and Reliability of Study Variables.

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Number of Steps T1	-																	
2. Number of Steps T2	.48**	-																
3. Number of Steps T3	.59**	.50**	-															
4. Number of Steps T4	.42**	.50**	.59**	-														
5. Number of Steps T5	.58**	.36**	.63**	.61**	-													
6. Number of Steps T6	.35**	.47**	.61**	.58**	.59**	-												
7. Emotional Strain T1	-.07	.10	.08	-.00	.01	-.04	(.86)											
8. Emotional Strain T2	.10	.10	.15	.21	.11	-.00	.72**	(.90)										
9. Emotional Strain T3	-.10	.21	-.04	-.09	-.05	.01	.76**	.81**	(.91)									
10. Emotional Strain T4	-.06	.26	.05	-.07	-.07	-.01	.77**	.91**	.89**	(.92)								
11. Emotional Strain T5	-.05	.17	-.04	-.11	-.12	.05	.74**	.75**	.88**	.87**	(.92)							
12. Emotional Strain T6	.06	.32*	.19	-.02	.10	-.00	.73**	.72**	.84**	.83**	.81**	(.86)						
13. Negative Affect T1	-.10	.33*	-.05	.07	-.04	.21	.53**	.35**	.52**	.53**	.42**	.47**	(.61)					
14. Negative Affect T2	.12	.23	.09	.32*	.21	.12	.30*	.55**	.46**	.49**	.36**	.34**	.40**	(.77)				
15. Negative Affect T3	-.21	.22	-.11	.01	-.11	.02	.42**	.54**	.68**	.68**	.54**	.51**	.45**	.33**	(.83)			
16. Negative Affect T4	-.03	.19	.05	-.01	-.06	-.02	.57**	.56**	.63**	.69**	.57**	.63**	.38**	.25	.64**	(.77)		
17. Negative Affect T5	.03	.38**	.07	.08	.05	.01	.64**	.54**	.53**	.55**	.64**	.63**	.36**	.36**	.46**	.59**	(.75)	
18. Negative Affect T6	.03	.25	.08	.08	.02	-.03	.62**	.64**	.67**	.78**	.64**	.69**	.50**	.50**	.57**	.72**	.67**	(.80)

Notes: * $p < .05$. ** $p < .01$.

Abbreviations: T1, Time 1; T2, Time 2; T3, Time 3; T4, Time 4; T5, Time 5; T6, Time 6.

to answer further questions about the intervention efficacy which are not proposed in our hypotheses (e.g., when the intervention begins to have an effect). The results of LCS are presented in the supplementary material.

Within all analyses, full information maximum likelihood (FIML) was used to handle missing data. Additionally, we used the cut-off criteria for the following goodness-of-fit indices by Brown (2006) to approximately evaluate the model fit: Comparative Fit Index (CFI) = close to .95; Root Mean Square Error of Approximation (RMSEA) = close to .06; Standardized Root Mean Square Residual (SRMR) = close to .08. As an interpretation for the relevance of the effects, we used standardized regression coefficients (β). A small effect was taken to be $\beta \leq .1$, a medium effect, $\beta \leq .5$, and a large effect $\beta \geq .5$ (Cohen, 1988). We decided to interpret the standardized regression coefficients because some of our measurements used smaller scales (e.g., emotional strain) whereas other measurements produced scores in the thousands (e.g., number of steps). However, unstandardized regression coefficients of all analyses can be found in Table 3.

Results

The zero-order correlations and Cronbach's alphas are shown in Table 2. The means and standard deviations of all study variables at all points of measurement are presented in Table 3. According to the recommendations of Stride (2014), we first looked at the development of each study variable visually before defining trajectories. Based on the development of each variable, we then defined the trajectories for the growth curve model resulting in one slope for every model. The development of the number of steps, emotional strain, and negative affect are displayed in Figures 2–4. However, regardless of the development of each variable, the intercept was coded with 0 in every model.

Patterns of change in number of steps

Our first hypothesis proposed that employees' number of steps increases during the intervention. Thus, we assumed that we would find a significant slope in a model showing increasing trajectories. To define the trajectories, we first looked at the development of the number of steps. As Figure 2 shows, the number of steps increased during the intervention. The greatest increase was in the second intervention week between T3 and T4 (see Figure 2 and supplementary material). Moreover, the development of the number of steps peaked at T4. To consider this development within the model slope, the trajectories of the growth curve were defined so that they show a linear increase in number of steps until T4 but no further increase afterwards. The defined model fitted the data acceptable, $\chi^2(16, N = 108) = 21.75$, $p = .151$; CFI = .97; RMSEA = .06; SRMR = .10. The model results revealed a significant positive slope with a medium effect size, $\beta = 0.43$, $p = .025$. Thus, with regard to Table 4, on average employees showed a significant increase of 290 steps between points of measurement. However, the analyses showed a significant slope variance, $\sigma^2_{\text{slope}} = 0.48$, $p = .045$, indicating that employees differed in their increase in number of steps during the intervention. Furthermore, the significant intercept variance revealed that employees showed a difference in their numbers of steps at the beginning of the intervention ($\sigma^2_{\text{intercept}} = 7.941$, $p = .000$). Additionally, the slope and the intercept of the number of steps correlated significantly ($\beta = -0.41$, $p = .028$). Thus, employees who already had a high number of steps at the beginning of the intervention showed a smaller increase in number of steps than did employees with a small number of steps at the beginning of the intervention. Based on these results, Hypothesis 1 was supported.

Table 3. Means and Standard Deviation for Study Variables at All Points of Measurement.

Variable	Means (Standard Deviation)						
	T0	T1	T2	T3	T4	T5	T6
Number of Steps	/	8,973 (3,526)	9,558 (3,291)	9,604 (3,552)	10,311 (3,334)	9,705 (3,933)	9,733 (3,294)
Job Control	3.27 (.86)	/	/	/	/	/	/
Self-Efficacy	3.23 (.60)	/	/	/	/	/	/
Emotional Strain	/	2.24 (.96)	2.10 (.96)	2.12 (1.09)	2.04 (1.09)	2.05 (1.13)	1.94 (.90)
Negative Affect	/	1.65 (.55)	1.64 (.65)	1.62 (.73)	1.48 (.60)	1.40 (.52)	1.44 (.55)

Notes: T0 = 108; T1 = 92; T2 = 71; T3 = 94; T4 = 77; T5 = 93; T6 = 81.

Abbreviations: T0, Time 0; T1, Time 1; T2, Time 2; T3, Time 3; T4, Time 4; T5, Time 5; T6, Time 6.

Table 4. Unstandardized Model Results.

Variables	Intercept		Slope		Moderator on Intercept		Moderator on Slope		Slope with Slope	
	B	(p)	B	(p)	B	(p)	B	(p)	B	(p)
Number of Steps	9.02	.000**	0.29	.008**	/	/	/	/	/	/
Job Control on Number of Steps	/	/	/	/	0.89	.135	−0.23	.208	/	/
Self-Efficacy on Number of Steps	/	/	/	/	1.50	.084	0.29	.314	/	/
Emotional Strain	1.64	.000**	−0.06	.000**	/	/	/	/	/	/
Number of Steps with Emotional Strain	/	/	/	/	/	/	/	/	−0.01	.394
Negative Affect	2.22	.000**	−0.05	.000**	/	/	/	/	/	/
Number of Steps with Negative Affect	/	/	/	/	/	/	/	/	−0.03	.012*

Notes: * $p < .05$. ** $p < .01$.

Abbreviation: The indication for number of steps is given in thousands. B, unstandardized regression coefficient.

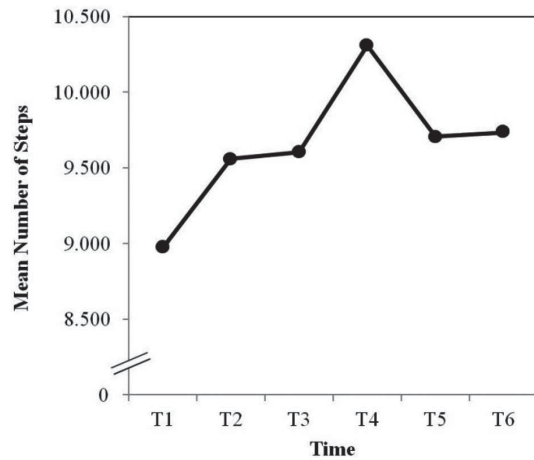


Figure 2. Development of means for number of steps between T1, T2, T3, T4, T5, and T6.

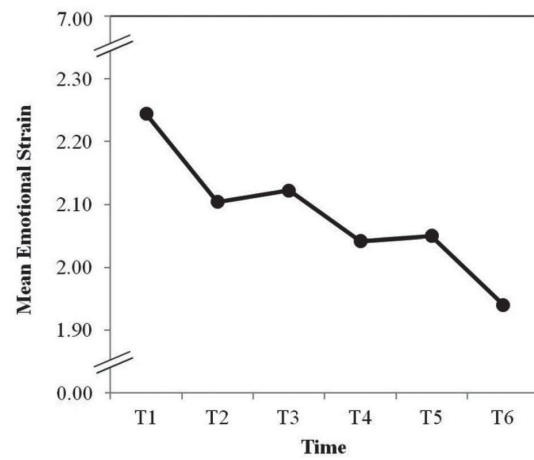


Figure 3. Development of means for emotional strain between T1, T2, T3, T4, T5, and T6.

Patterns of change in number of steps in relation to job control

In the second hypothesis, we assumed that employees with a higher level of job control show a higher increase in number of steps than employees with a low level of job control. Therefore, job control was expected to be significantly associated with the slope representing number of steps. The model showed an adequate fit to the data, $\chi^2(30, N = 108) = 41.55$, $p = .078$; CFI = .95; RMSEA = .06; SRMR = .11. Nevertheless, the analyses revealed an association between the intercept ($\beta = 0.23$, $p = .077$) and the slope of number of steps ($\beta = -0.25$, $p = .277$) with a medium effect size which was not, however, significant. Hence, in our sample, Hypothesis 2 was not supported.

Patterns of change in number of steps in relation to self-efficacy

To test Hypothesis 3, we analysed whether self-efficacy at T0 was related to the slope of the number of steps. The defined model fitted the data sufficiently, $\chi^2(31, N = 108) = 36.72$, $p = .221$; CFI = .97; RMSEA = .04; SRMR = .12. The model results showed a relation to the intercept of the number of steps ($\beta = 0.27$, $p = .073$) and the slope of number of steps ($\beta = 0.21$, $p = .307$) which did not reach significance within our sample. Thus, Hypothesis 3, the assumption that self-efficacy moderates the increase in number of steps, was not supported.

Patterns of change in emotional strain

Hypotheses 4 and 5 were tested within one model, which showed a good fit to the data, $\chi^2(146, N = 108) = 201.52$, $p = .002$; CFI = .96; RMSEA = .06; SRMR = .08. Our fourth hypothesis proposed that emotional strain decreases over the course of the intervention. With regard to Figure 3, we defined the linear trajectories decreasing from T1 to T6 for

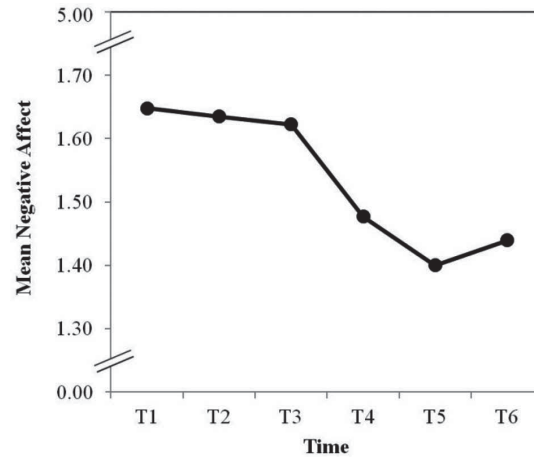


Figure 4. Development of means for negative affect between T1, T2, T3, T4, T5, and T6.

emotional strain. The model results revealed a significant decrease in emotional strain from T1 to T6 with a large effect size, $\beta = -0.79$, $p = .011$. On average employees decreased their emotional strain by 0.06 points between measurement points on the Irritation Scale by Mohr, G. Mohr, Müller et al. (2005; see Table 4). Given that the slope variance was small, there was no significant variation in the decrease in emotional strain during the intervention ($\sigma^2_{\text{slope}} = 0.01$, $p = .094$). However, the model results showed a significant intercept variance, $\sigma^2_{\text{intercept}} = 0.92$, $p = .000$, indicating that employees differed in their levels of emotional strain at the beginning of the intervention. Based on the results pointed out earlier, Hypothesis 4 was supported.

Hypothesis 5 was that the decrease in emotional strain is associated with the increase in number of steps. Hence, we tested whether the slope of the number of steps is related to the slope of emotional strain. The analyses revealed a negative

association between the slope of number of steps and the slope of emotional strain with a medium effect size, which did not reach significance within our sample, $\beta = -0.26$, $p = 0.397$. Thus, in our sample, Hypothesis 5 was not supported.

Patterns of change in negative affect

The model to test Hypotheses 6 and 7 showed an adequate model fit to the data, $\chi^2(146, N = 108) = 210.27$, $p = .000$; CFI = .91; RMSEA = .06; SRMR = .11. The sixth hypothesis proposed that negative affect decreases during the intervention. Therefore, we defined decreasing trajectories for the growth model with regard to Figure 4. The analyses revealed a significant negative slope with a large effect size showing that negative affect decreased over the course of the intervention, $\beta = -0.76$, $p = .020$. With regard to Table 4, employees reduced their negative affect by an average of 0.05 points between points of measurement. Additionally, the model showed no significant slope variance ($\sigma^2_{\text{slope}} = 0.00$, $p = .136$), which indicates that there is no significant variation in the reduction of negative affect within our sample. Nevertheless, the analyses revealed a significant intercept variance, $\sigma^2_{\text{intercept}} = 0.12$, $p = .004$, showing that employees differed in their negative affect at the beginning of the intervention. Given the results pointed out earlier, Hypothesis 6 was supported.

To test Hypothesis 7, which was that the decrease in negative affect is associated with the increase in number of steps, we analysed whether the slope of the number of steps was related to the slope of negative affect. The model results revealed a significant association between the slope of the number of steps and the slope of negative affect with a large effect size, $r = -0.74$, $p = .028$. As shown in Table 4, on average, one unit increase in steps (i.e., 1000 steps) went along with a decrease in employees' negative affect equal to 0.03 points on the PANAS. Thus, Hypothesis 7 was supported.

Discussion

The present study aimed to evaluate the effect of an intervention including activity trackers on employees' number of steps and impaired well-being (i.e., emotional strain and negative affect). By applying LGCM to intervention data collected from mainly low active employees, we were able to obtain a detailed insight into the development of physical activity and impaired well-being during the intervention. Thus, we furthermore tested whether the increase in number of steps was moderated by job control and self-efficacy and if the increase in number of steps was associated with the decrease in impaired well-being. In the following sections, the effect of the cognitive-behavioural intervention on number of steps, emotional strain, and negative affect will be discussed in detail.

Intervention effect on number of steps

In line with previous intervention studies that included activity trackers, the employees in our study showed an increase in number of steps (Abrantes et al., 2017; Cadmus-Bertram et al., 2015; Finkelstein et al., 2016; Wang et al., 2015). By considering six points of measurement during the intervention, we

additionally showed that employees' number of steps increased until the end of the second intervention week (T4). This finding confirms the results of the studies by O'Brien et al. (2015) and Wang et al. (2015) showing that number of steps mainly increased in the first weeks of an intervention. It might be possible that this effect was caused by the novelty or initial excitement about the intervention. Nevertheless, this explanation is not very likely because the employees walked more steps at all points of measurement than at the beginning of the intervention. Thus, we rather assume that the step challenge, which we conducted in the second intervention week, was especially effective in motivating employees, which in turn may have caused the pattern of change in number of steps. As previous studies have shown that different social challenges or competitions can be an effective tool for increasing the number of steps (Foster et al., 2010; Leininger et al., 2014; Prestwich et al., 2017), future studies might include a challenge as an extra motivational component to increase employees' physical activity.

Moderation effect of job control and self-efficacy

Contrary to our hypotheses, we could not find an effect of job control or self-efficacy on the increase in employees' number of steps. With regard to job control, this might be because the intervention activities could also be performed away from work. In contrast to our study, Cifuentes et al. (2015) found a positive relationship between intervention effectiveness and high job control used in an intervention which could only be conducted during working hours. Thus, the potential effect of an intervention integrated into daily work routines could be higher for employees with high job control might be reduced in our study because employees might have also performed the intervention outside of work.

In relation to self-efficacy, we also found no significant relation between self-efficacy and the increase in number of steps. It is possible that our intervention alone increased self-efficacy among employees. Since previous studies have shown that behavioural change techniques such as self-monitoring or action planning benefit self-efficacy (Gleeson-Kreig, 2006; Olander et al., 2013; Williams & French, 2011), our intervention might not only have improved physical activity but also have increased self-efficacy. Another possible explanation why we could not find a significant relationship between self-efficacy and employees' increase in number of steps might be that self-efficacy fluctuated over the course of the intervention. We only measured self-efficacy related to physical activity before the intervention (T0). However, previous studies found that 38–63% of the variance in self-efficacy fluctuates on a daily basis (Tims et al., 2011; Xanthopoulou et al., 2008). Thus, it is likely that self-efficacy regarding physical activity also fluctuates over time. Therefore, future studies should include measurements of self-efficacy at the time point when physical activity data are collected.

Intervention effects on impaired well-being

In agreement with our hypotheses, we found a significant improvement in employees' impaired well-being (i.e.,

emotional strain and negative affect). Thus, our findings confirm the results of previous studies showing that negative affect and stress indicators such as emotional strain can be reduced through workplace interventions related to physical activity (Bruin et al., 2017; Conn et al., 2009). Because the study had a longitudinal design with six points of measurement, we were able to show that employees improved their impaired well-being over the course of the intervention. Further analyses showed that the increase in number of steps was significantly associated with decrease in negative affect, but that no such association could be found for emotional strain. A possible explanation for this finding could be that the Irritation Scale by G. Mohr, Rigotti et al. (2005) which we used to operationalize emotional strain is rather work oriented. As proposed by the triple-match principle (TMP), associations between variables are more likely to be found when concepts are considered to be related to an identical dimension (De Jonge & Dormann, 2003, 2006). Since the number of steps is a rather general variable whereas emotional strain is a work-focused stress indicator, it might be more difficult to find an association between these two variables.

Another explanation for why the observed reduction in emotional strain was not associated with increase in number of steps could be that our intervention included several features which may have reduced employees' emotional strain. In particular, the activity tracker provides various features besides collecting and monitoring information in relation to physical activity (e.g., number of steps and energy consumption) which could also be used to improve other health behaviours. For instance, the activity tracker also provides information about sleep. Previous studies have shown that sleep deprivation is associated with higher stress among employees (Meerlo et al., 2008; Minkel et al., 2012; Schwarz et al., 2018). Thus, it might be possible that employees not only focused on increasing their number of steps but also tried to improve their sleep quality so that the decrease in emotional strain might be caused by other mechanisms. Because we do not have any data on how employees used the features of the activity tracker, future studies should further investigate which features are effective in improving impaired well-being among employees.

Limitations and future research

Our study is not without limitations which will be discussed together with implications for future research in the following. Even though our study design enabled us to apply LGCM to the data, which gave us a detailed insight into the development of physical activity and impaired well-being during the intervention, we did not include a control group in our study. Thus, it is not possible to fully rule out the possibility that the intervention effects were influenced by contextual factors (e.g., time of the year when the study started). To reduce this confounding influence, we conducted the intervention in two randomized groups that participated consecutively in the intervention activities, making the possible influence of the time of year less likely. Nevertheless, future studies should include a control group in their study design so that the influence of

contextual factors can be fully excluded. Additionally, we have no information as to whether the employees maintained the improvement in number of steps and impaired well-being after the end of the intervention. Thus, future studies should also examine long-term effects to determine the sustainability of the intervention effects on the considered outcome variables.

One major strength of our study was that we used the activity data collected by the activity tracker to operationalize physical activity. Nevertheless, due to the regulations of the data security policy and the works council of the company in which we recruited participants, this objectively recorded data could only be assessed through self-report. It would be desirable if future studies could take the registered activity data directly from the activity tracker (or the activity tracker's app) to further increase the objectivity of the activity data. Additionally, although overall all measures considered in this study showed a satisfactory reliability, negative affect had a rather low Cronbach's alpha at T1 which may have reduced the precision of this specific measurement at that particular point of measurement.

Since there were no previous studies providing information about the effect sizes yielded by an intervention using equivalent elements (i.e., activity tracker and online coach) in a workplace setting, we were not able to calculate the optimal sample size. However, a meta-analysis evaluating the effect of pedometers (the predecessor of activity trackers; i.e., a device that simply tracks steps, no further health-related data) on the number of steps in a non-workplace setting offers an effect size of 0.84 (Kang et al., 2009). Compared to our study, we found much smaller effect sizes, which, despite having high data quality (e.g., objectively reported activity data) did not reach significance in our sample. This discrepancy is in line with recent research showing that meta-analyses tend to overestimate effect sizes (Kvarven et al., 2019). Thus, researchers planning future studies should note that, in spite of the fact that high-quality data allow for higher precision, and hence power, large sample sizes are still necessary to detect smaller effects. Additionally, the effects found in our study could serve as a guideline for calculating the optimal sample size for future high-powered replication studies. Furthermore, given the considerable slope variance in our study, future studies having larger sample size could also use latent class analysis (LCA) for identifying groups of employees who are similar in their behaviour change during the intervention (Nylund et al., 2007). Explaining these latent classes could be an interesting research question for future studies.

Another possible limitation of our study might be that the generalizability of our results could be reduced because the sample was recruited from only one company in Germany. However, by recruiting from one large company in Germany, we were able to access a population of mainly low active employees which is rarely considered in intervention studies. Nevertheless, future studies should question whether an intervention with activity trackers is suitable for improving physical activity and health in a different population. It is possible that increasing self-monitoring of health data through activity trackers among healthy employees, who are already physically active, is less effective than among mainly low active employees.

Practical implications and conclusion

The results of our study show that the use of activity trackers supported by a cognitive approach benefits employees' physical activity and impaired well-being (i.e., emotional strain and negative affect). Because these outcomes are related to employees' job satisfaction, absenteeism, and performance (Bashir & Ramay, 2010; Bowling et al., 2010; Leontaridi & Ward, 2002; Parks & Steelman, 2008; Shockley et al., 2012), we created an intervention that is highly valuable for employers as well as employees. Given that activity trackers are not expensive and that the online coach could be programmed at a relatively low cost, the intervention is a cost-effective approach to improve physical activity and impaired well-being in the work setting. Moreover, activity trackers are easily accessible (can be used anywhere, at any time; Borrelli & Ritterband, 2015), so that they constitute a cost-effective new technology which can possibly be used by employees doing different jobs. However, although we did not find a moderation effect of job control, a health-oriented working environment could help employees to reach the recommended activity goals (Fransson et al., 2012; Griep et al., 2015; Heikkilä et al., 2013). Thus, practitioners need to focus on creating a health-oriented workplace as well as promoting effective interventions, such as the one presented in this study, to improve health among employees.

In summary, our study reveals that employees performing the cognitive-behavioural intervention showed an increase in number of steps taken with a medium effect size and an improvement in impaired well-being (i.e., emotional strain and negative affect) with a large effect size. Moreover, job control and self-efficacy did not seem to have an influence on the increase in the number of steps within our sample. Additionally, this study contributes to the existing literature on workplace physical activity interventions by analysing the development of physical activity, emotional strain, and negative affect during an intervention. We showed that employees increased their number of steps up to the second intervention week and that the general increase in number of steps over the course of the intervention was not related to the decrease in emotional strain but significantly associated with the decrease in negative affect. Overall, we therefore conclude that the use of activity trackers combined with a cognitive approach constitutes an effective intervention to improve physical activity and impaired well-being among employees.

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Disclosure statement

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Supplementary Material: Additional Analyses

Besides the latent growth curve model (LGCM) which we used to test the pattern of change proposed in our hypotheses, additional analyses were conducted using a latent change score modelling approach (LCS). LCS has already been used in the I/O psychology literature (e.g., Hoppe, Toker, Schachler, & Ziegler, 2017; Li, Li, Fay, & Frese, 2019) and is an ideal complement to LGCM since change can be modelled using only two points of measurement (McArdle, 2009; Selig & Preacher, 2009). Thus, we were able to answer questions which could not be addressed by the LGCM approach. By using a baseline LCS we could determine when the intervention starts to yield effects regarding the different outcome variables (i.e. number of steps, emotional strain, and negative affect), since baseline LCS defines change scores between baseline and each point of measurement (e.g. T1-T2; T1-T3; T1-T4). Additionally, we also conducted neighbour LCS to compare the extent of change between points of measurement and ascertain when the change in number of steps and impaired well-being (i.e., emotional strain and negative affect) is at its strongest during the intervention. Contrary to baseline LCS, neighbour LCS determines change by considering consecutive points of measurement (e.g. T1-T2; T2-T3; T3-T4).

In our analyses, both LCS models (i.e. baseline modelling and neighbour modelling) were based on latent variables so that specified change scores were free of measurement errors (McArdle, 2009). Only the models of number of steps did not use latent variables due to the manifest nature of the variable number of steps. To evaluate how the defined models fitted the data, we used the following goodness-of-fit indices and cut off-values proposed by Brown (2006): Comparative Fit Index (CFI) = close to .95; Root Mean Square Error of Approximation (RMSEA) = close to .06; Standardized Root Mean Square Residual (SRMR) = close to .08. Moreover, Cohen's d was used to interpret the relevance of the effects: $d \leq .14$ = small effect; $d \leq .35$ = medium effect; $d \geq .57$ = strong effect (Cohen, 1988). For the interpretation of the effects we used standardized regression coefficients. Nevertheless, Table

A2 and Table A3 present the standardized regression coefficients together with the unstandardized regression coefficients.

Baseline Latent Change Score Models

Model fit indices for all baseline LCSs can be found in Table A1. An overview of the results for all study variables (i.e. number of steps, emotional strain, and negative affect) is presented in Table A2. With regard to the increase in number of steps, Table A2 shows that the first significant increase in number of steps was found between T1 and T3 with a medium effect size within our sample. Thus, given our sample size, employees required one intervention week before they could significantly increase their number of steps in comparison to the beginning of the intervention. In relation to emotional strain, the results revealed a significant reduction between T1 and T4 with a medium effect size. This finding shows that the employees in our sample had to engage in the intervention until the end of the second intervention week before experiencing a significant reduction in emotional strain. Furthermore, Table A2 shows that negative affect was significantly reduced for the first time with a large effect size between T1 and T5, which indicates that it took two weeks for the intervention to promote the reduction of employees' negative affect within our sample.

Neighbour Latent Change Score Models

Table A1 shows the model fit indices of all neighbour LCSs. The results of the neighbour LCSs for all study variables (i.e., number of steps, emotional strain, and negative affect) are presented in Table A3. Regarding number of steps, no significant increase could be found between consecutive points of measurement (e.g. T2-T3) within our sample. The results likewise showed no significant reduction in emotional strain and negative affect between consecutive points of measurement. These findings are not surprising since there is no theoretical reason to expect a significant improvement in number of steps or impaired well-being (i.e. emotional strain and negative affect) between two consecutive points of

measurement during the intervention. Additionally, given our sample size, effect sizes ranging from .01 to .28 were not statistically significant.

Nevertheless, the neighbour LCS provides information about the extent of change between points of measurement. Thus, the neighbour LCS for number of steps showed that employees increased their number of steps markedly in the second week of the intervention (between T3 and T4) whereas the greatest reduction in employees' emotional strain was at the beginning of the intervention (T1-T2). As shown in Table A3, the results for negative affect revealed that employees' negative affect diminished most markedly at the end of the second intervention week (between T4-T5).

Table A1

Model fits for baseline latent change score models and neighbour latent change score models

Variables	χ^2/df (p)	CFI	RMSEA	SRMR
Number of Steps*	/	/	/	/
Emotional Strain	86.77/48 (.001)	0.97	0.09	0.04
Negative Affect	62.37/48 (.080)	0.97	0.05	0.08

Note. Model fit indices apply to both latent change score models (i.e. baseline LCS and neighbour LCS), since the models are equivalent given the same amount of estimated parameters. Only the definition of change scores differs. CFI = comparative fit index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual.

*The baseline LCS and neighbor LCS for number of steps is a saturated model. Therefore there are no model fit indices available.

Table A2

Results for the baseline latent change score model

	$\Delta T1-T2$		$\Delta T1-T3$		$\Delta T1-T4$		$\Delta T1-T5$		$\Delta T1-T6$	
Variable	$\beta (p)$	$B (p)$	$\beta (p)$	$B (p)$	$\beta (p)$	$B (p)$	$\beta (p)$	$B (p)$	$\beta (p)$	$B (p)$
Number of Steps	0.14 (.226)	0.48 (.223)	0.24 (.028*)	0.74 (.025*)	0.36 (.002**)	1.33 (.001**)	0.23 (.037*)	0.77 (.033*)	0.18 (.086)	0.72 (.084)
Emotional Strain	-0.23 (.092)	-0.14 (.085)	-0.25 (.053)	-0.15 (.045*)	-0.33 (.010*)	-0.21 (.007**)	-0.41 (.003**)	-0.26 (.001**)	-0.47 (.000**)	-0.32 (.000**)
Negative Affect	-0.06 (.731)	-0.03 (.733)	-0.07 (.632)	-0.04 (.630)	-0.30 (.067)	-0.14 (.046*)	-0.57 (.001**)	-0.27 (.000**)	-0.39 (.013*)	-0.19 (.005**)

Note. $\Delta T1-T2$ = latent change score between Time 1 and Time 2; $\Delta T1-T3$ = latent change score between Time 1 and Time 3; $\Delta T1-T4$ = latent change score between Time 1 and Time 4; $\Delta T1-T5$ = latent change score between Time 1 and Time 5; $\Delta T1-T6$ = latent change score between Time 1 and Time 6.

β = standardized regression coefficient; B = unstandardized regression coefficient (the indication for number of steps is given in thousands)

* $p < .05$. ** $p < .01$.

Table A3

Results for the neighbour latent change score model

	$\Delta T1-T2$		$\Delta T2-T3$		$\Delta T3-T4$		$\Delta T4-T5$		$\Delta T5-T6$	
Variable	$\beta (p)$	$B (p)$	$\beta (p)$	$B (p)$	$\beta (p)$	$B (p)$	$\beta (p)$	$B (p)$	$\beta (p)$	$B (p)$
Number of Steps	0.14 (.226)	0.48 (.223)	0.08 (.503)	0.26 (.501)	0.19 (.095)	0.59 (.094)	-0.17 (.134)	-0.55 (.130)	-0.02 (.885)	-0.05 (.885)
Emotional Strain	-0.23 (.092)	-0.14 (.085)	-0.03 (.853)	-0.01 (.853)	-0.15 (.277)	-0.06 (.271)	-0.08 (.515)	-0.05 (.515)	-0.12 (.364)	-0.06 (.357)
Negative Affect	-0.06 (.731)	-0.03 (.733)	-0.01 (.924)	-0.01 (.924)	-0.23 (.126)	-0.11 (.116)	-0.28 (.053)	-0.12 (.048*)	0.21 (.121)	0.08 (.120)

Note. $\Delta T1-T2$ = latent change score between Time 1 and Time 2; $\Delta T2-T3$ = latent change score between Time 2 and Time 3; $\Delta T3-T4$ = latent change score between Time 3 and Time 4; $\Delta T4-T5$ = latent change score between Time 4 and Time 5; $\Delta T5-T6$ = latent change score between Time 5 and Time 6.

β = standardized regression coefficient; B = unstandardized regression coefficient (the indication for number of steps is given in thousands)

* $p < .05$. ** $p < .01$.

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