Self-initiated nudging for physical activity: A diary study

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Abstract

Physical inactivity has become a widespread epidemic in recent times. This stems from the fact that people often make biased decisions when it comes to physical activity (PA). In this study, we use behavioral economics literature and studies on behavior change to argue that individuals may utilize self-initiated nudges as tools to overcome those biases. We gathered nudge data by interviewing and systematic web search, and created a 13-item daily self-initiated nudging scale. We conducted a ten-day diary study with 41 employees from two real estate companies. The results showed that self-initiated nudging can be reliably measured with 11 items from the scale, which loaded on three distinct factors: work specific factor, fitness-related socializing factor and self-monitoring factor. All three factors were positively associated PA at work, while the two latter factors also positively linked with PA outside of work, vigorous type in particular. Further analyses showed that the general level of PA was a moderating factor between self-initiated nudging and PA outside of work, with moderately active individuals benefited the most from self-initiated nudges, followed by the group that was not very active. Organizational exercise climate did not moderate the relationship between self-nudging and PA. In addition, both daily PA at work and PA outside of work were found to be positively associated with the daily energy, while only PA outside of work was positively related to daily workplace mental health. Finally, daily PA was not associated with daily in-role or extra-role performance.

KEYWORDS

Self-initiated nudging; physical activity; energy level; workplace mental health; work performance.

With the rise of the economy and technological advancements worldwide, the amount of physical labor and physical activity has been greatly reduced. Hardship from physical exertion has been substantially reduced, and people can travel over considerably longer distance without any physical energy expenditure (Ng & Popkin, 2012). However, all the benefits seen above come at the cost of physical inactivity (Fotheringham, Wonnacott & Owen, 2000). This level of physical activity (PA), in fact, steadily decreases over the decades as technologies progress (Lakdawalla & Philipson, 2009). This increasingly sedentary lifestyle trend has been identified as a risk factor for a variety of physical and mental health issues (Saunders, Chaput & Tremblay, 2014).

Indeed, there is substantial evidence to show that physical inactivity is a major contributor to death and disability from non-communicable diseases worldwide. Since 2005, organizations such as the WHO and the CDC has been part of a worldwide effort to implement action on non-communicable diseases (Ding et al., 2016). Increasing the level of PA is one such priority (Das & Horton, 2012). The reason is simple, PA is consistently found to be both preventive and curative in different samples and with different methodological approaches. For example, exercise-based stress-reducing effects were also found in cross-sectional studies, prospective, longitudinal and quasi-experimental investigations (Gerber & Pühse, 2009). There is evidence to suggest that three 60-minute sessions of moderate physical activity per week have a wide range of cognitive and anti-aging benefits (Chapman et al., 2016). A lot of studies have shown that exercise can even be prescribed to treat some existing heart conditions (Franklin, Swain & Shephard, 2003; Hambrecht et al., 1993).

The question remains, with overwhelming evidence pointing towards the cost of physical inactivity and the benefits that are associated with PAs, why there are tremendous individual differences when it comes to people's engagement in PAs.

The truth of the matter is, even though most people are aware of the multi-faceted benefits that being physically active can generate, or at least are not completely oblivious to the consequences of physical inactivity, the majority of those people might not take any action (Stetson et al., 1997). It is therefore not surprising that, despite being one of the healthiest habits, being physically active has seen the greatest intention-behavior gaps of them all (Sniehotta et al., 2005). The fact that more than 2/3 of people in the USA are overweight and roughly 23% of them are morbidly obese, reflects this gap of making rational choices related to PA. It is because in an ideal world, no one would ever want to be overweight, let alone obese (Carr & Friedman, 2005). Yet, the WHO has announced that obesity has become an epidemic, with the percentage rises steadily over the years (WHO, 2018).

Behavioral economic theories suggest that the discrepancy above is the results of having two intertwined systems, which are called system 1 and system 2, respectively (Kahneman & Egan, 2011). System 1 is fast, automatic, and highly susceptible to environmental influences; System 2 processing is slow, analytical, reflective, and takes into account explicit goals and intentions. Thaler (1998) put forward that people often do things that contradict with their rational interests or collective good, even if they are fully aware of the matter. This is due to the limited capacity of system 2. For this particular reason, system 2 could be easily overridden by system 1, which is faster and has no capacity limits. The problem is that system 1 is built upon heuristics and ingrained habits, which is very problematic when they are maladaptive. Research in eating habits, for example, one that was conducted by Jansen et al. (2003), describes that when a junk food addict seeks to reduce their junk food consumption, he or she has to use rationality to overcome the habit of buying and consuming unhealthy foods. This is an uphill battle, where something as mild as familiar routes or smells can trigger the habit, especially when their willpower is compromised, such as when they are tired or hungry (Jansen et al., 2003). This is precisely where nudging comes in as a valuable tool.

Definition and types of nudges

Originally proposed by Thaler and Sunstein (2008), a nudge is defined as an aspect of the environment that affects people's behavior in a predictable way, without banishing or disallowing any of the other choices. In this way, nudging means a systematic adjustment to some aspect of the surroundings, resulting in a choice architecture change which in turn, leads to changes in behavior, without disrupting the amount of choices available or the level of incentives. Thaler and Sunstein (2008) give an example that putting fruits and healthy food options at the eye level in the school cafeteria is a nudge, whereas banning junk food is not.

As we have mentioned earlier, system 2 represents an individual's cognitive capacity, which is limited but can result in deliberate and considered choices that reflect shifting priorities and values. Many public health initiatives are directed at this capacity by focusing on providing information and assisting the self-creation and regulation of long-term goals through different forms of motivation and incentivization. System 1, by contrast, is automatic and sub-conscious, and is largely conditioned by the environment in which choices are made. Thus, one may speculate that by initiating nudges themselves, individuals can take the step to mindfully fortify the priorities and the rationality of system 2 or proactively take action to modify the environment for system 1, thereby they do not have to be at the mercy of the environment they find themselves in.

According to Ly and colleagues (2013), there are two ways nudges can be presented to individuals (see appendix A). Nudges can be categorized by whether they are externally-imposed or self-imposed. Externally-imposed nudges, as the name suggested, are nudges imposed by some other party. Self-imposed, or self-initiated nudges, on the other hand, are initiated by people who themselves think they might have self-control slips. These are the individuals who might want to impose a nudge on themselves to help make sure that they, in fact, follow through on the chosen action. This is the type of nudge we will investigate in this article.

The way a nudge affects people's behaviors is conceptualized through the two systems (Sunstein, 2016). A system 2 nudge is one that increases cognition and gets people to think a little more about their decision at hand, in other words, gives system 2 a boost. System 1 nudges, on the other hand, go the opposite way, that is to modify the existing content in the environments to discourage system 1 slips.

Mechanisms of system 1 nudges

There are different theorized mechanisms by which each type of nudge can help with the desired physical activities. System 1 or mindless nudges is the type of nudges aimed at changing human behavior indirectly, without the person being conscious of it. These often include subtle or indirect changes in how something is presented, which can play a significant role in the choices people make (House & Lyons, 2013). Thus, by deliberately making use of them, individuals could improve their decision making towards healthier choices without much thought (Ly et al., 2013). Below, we will discuss ways mindless nudges could work.

Default. One of the most common nudges is to make the desired behavior the "default" option. From the individual perspective, it is simpler to keep on doing things that have been part of a routine (Sunstein, 2016). This means if someone's routine includes exercising, it is easier for that individual to keep on doing, rather than to skip the exercises (Aarts, Paulussen & Schaalma, 1997).

Framing. Another common type of nudge is to present the same situation from a different perspective, which is called "framing." For example, research has shown that people are more motivated to make a decision if it is framed in terms of minimizing potential losses rather than maximizing potential gains. This is known in psychology as "loss aversion." Consequently, if a situation is presented in terms of what someone will *lose* or "miss out" on is often better at changing behavior than focusing on what they will *gain (*Kahneman & Tversky, 2003).

Environment. Anything in someone's environment could be a potential influence on their thoughts and behaviors. Studies have illustrated a wide range of examples, such as fitness-related

posters in one's environment have an impact on his or her fitness level (Sallis et al., 2003; Dunton et al., 2007; Johansen, 2016). People can certainly make use of this, and make something which encourages physical activities part of their environment.

Social Influence. Another big unconscious motivator of people's choices is social influence. When someone sees other people behave a certain way, they tend to mimic their decisions. This is known as the "bandwagon effect." At an unconscious level, an individual could think that if a lot of other people are making this choice, then it must be a good choice and I will do it too (Dietrich, 2010). Thus, it is highly probable that by manipulating the social factors that influence the individual, such as surrounding oneself with people who are regular exercisers, one may expect to raise the exercise level as well (Dunton et al., 2007).

Mindless nudge may be effective, because an individual typically faces too much of a cognitive overload on a daily basis. Thus, system 1, or mindless nudges, make it easy for individuals to move towards the desired outcomes by placing individuals in better conditions to carry out the acts that are more inclined with their best interests. For example, a person who wants to quit junk food consumption may benefit from changing the routes, preparing meals for themselves or having graphic reminders in their vehicles. Changing routes and self-preparing meal may help because individuals do not have to face the triggers anymore and therefore, do not have to exert willpower to overcome it (Li & Chapman, 2013). On the other hand, a graphic reminder may also be effective, because it gives the automatic system 1 a warning, which could slow it down and give space to the rational system (Li & Chapman, 2013).

Mechanisms of system 2 nudges

On the contrary, system 2 or mindful nudges are ways of changing human behavior by making a person more conscious of the choice they are making. Many people make regrettable decisions or give in to temptations without truly thinking through. Mindful nudges are a way to make people re-evaluate exactly what type of choice they want to make next (Sunstein, 2016).

Setting/ Eliminating Boundaries. The more steps it takes to make a choice, the harder that choice is to commit to. This principle can be very effective in curbing unhealthy habits. By creating extra "boundaries" between themselves and their bad choices, people could make it increasingly more difficult to continue to relapse into those choices. The opposite is also true for desired behaviors, the less steps it takes, the easier it is to carry them out (Thaler, 1998; Thaler & Sunstein, 2003). For example, there are findings that some people mind walking due to the uncomfortable office footwear, such as high heels, so a pair of comfortable running shoes under the work desk may be a good idea (Menant, Perry, Steele, Menz, Munro & Lord, 2008).

Alerts and reminders. Setting an alert on a smartphone or computer is another type of mindful nudges that can make people more conscious of their daily choices. For example, if a person has trouble getting up at work, then he or she may want to set an alert on their computer every 2-3 hours. This alert can serve as a reminder that the user needs to get out of the zone and take a break. Whenever an alert goes off, the individual is reminded to re-evaluate what he or she is doing in the present moment, and decide to continue doing it or start something else. Earlier research has seen some efficacy of reminders, such that of a common alert nudge which was observed among some workers is a note from their computers reminding them to stretch for a minute or two after a certain interval (Griffiths, Mackey & Adamson, 2007; Monsey et al., 2003).

Progress monitoring. In order to commit to a decision, it helps tremendously that individuals see they are making progress toward a goal. Without this feeling of progression, they become far more likely to become demotivated and abandon a goal. By creating "progress points" – such as estimated times or signposts – people can physically see that progress is being made. This feedback, together with setting appropriate rewards for each progress point, could be one of the most powerful sources of motivation for any behaviors to persist (Michie et al., 2009; Sazlina, Browning & Yasin, 2015; Kongstad et al., 2017). Thus, it is not so surprising that, self-rewarding act every time a definitive physical activity is carried out (e.g., a cup of coffee after a walk), was shown to increase the likelihood of that activity to be repeated again (Charness & Gneezy, 2009).

The Present Study

Although we have just discussed the theoretical basis on which self-initiated nudges work, there has not been much empirical evidence supporting its effectiveness in promoting PA. Most studies in the domain of self-initiated nudge often either use case reports, or look at very brief behaviors that do not lead to considerable long-term health benefits. Therefore, in this study, we will systematically investigate the effectiveness of self-initiated nudges in helping decision makers avoid biases and inconsistencies related to physical activities on a daily basis, over a period of time.

Regarding PA, it is defined as any bodily movement produced by skeletal muscles that results in energy expenditure (Caspersen, Powell & Christenson, 1985). It should be pointed out that there are different types and levels of PA. Physical activities in daily life can be divided into occupational, (recreational) sports, household, or other activities (Caspersen, Powell & Christenson, 1985). In this study, we will utilize a slightly different categorization of physical activity, by putting them into only two categories, which is PA during work and PA outside of work (i.e., leisure-time PA).

All these activities can also be categorized by the level of physical exertion, from light intensity, to moderate, and to vigorous level (Lee & Paffenbarger Jr, 2000). Light intensity is when there is only a slight level physical exertion and heart rate change. The person can keep on doing the activity for a long period of time, even while doing something else. Moderate level, however, requires a lot more effort and the heart rate is significantly elevated, probably passing 100 beats per second for most people. The performing person may still be able to talk, but would definitely not be able to do it for longer than a few seconds. Lastly, vigorous intensity level is significantly effortful and close to the all-out exertion level (i.e., sprinting level of exertion). At this level of physical exertion, the person in action cannot sustain the activity for a long duration (Caspersen, Powell & Christenson, 1985). For this study, we will only keep track of time spent on moderate and vigorous intensity activities, because these are the types most people are not doing enough (Hallal et al., 2012, Haskell et al., 2007).

Our main question is to explore whether setting up a nudge for themselves could help people increase the chance of them carrying out their desired physical activities, from taking more stretch breaks to walking or use the staircases more, to taking part in physical exercises during and outside of work hours. The ideal population for this study would be office workers. The first reason is office workers represent the majority of the workforce at the present time. Secondly, office workers, have long been found to not only have significantly more hours of sitting, but also be less active outside of work, compared to blue-collar worker or service workers (Gans et al., 2016). Nonetheless, it has been acknowledged that employees are becoming more proactive in many aspects, and can take charge in changing themselves and their environment (Parker, Bindl, & Strauss, 2010). This may be true, especially with their health and fitness area, where office employees are increasingly aware of the negative health consequences of excessive sitting (Daneshmandi, Choobineh, Ghaem & Karimi, 2017). We have discussed some of the proactive countermeasurements from the office workers to encourage daily physical activity, such as the use (software) reminders to encourage themselves to take more stretch breaks, or pairing their coffee break with a short walking session (Monsey et al., 2003; Charness & Gneezy, 2009). Thus, we expect that there are even more creative and proactive daily self-initiated nudging behaviors among them, which have not been captured by scientific literature. We also believe there are merits to those self-initiated nudging behaviors, as they do seem to have the potential to help the office workers become more physically active.

Hypothesis 1: Daily self-initiated nudging is positively related to daily physical activity.

However, there are certain caveats to the range of effectiveness of the nudges. We theorized where the individual stands on the physical activeness spectrum would play a role in how much they need help from the nudges. We have discussed that being physically active is a habit, and thus functions like a habit, despite being among the most challenging habits to develop. Indeed, the majority of people abandon their health-related goals at an early stage (Norcross et al., 1988). It was found that up to 80% of exercise-related New Year's resolutions never get pass the end of January. It could be that at this newly adopting phase, individuals often faced with major obstacles and disruptive changes in their life and therefore need support the most (Reeves, 2007; Mann, De Ridder, & Fujita, 2013). Thus, we argue that nudges will be most advantageous and therefore needed when people are not so active to begin with. Undeniably, most health and fitness apps aim to support the initial stage of behavior formation process. These apps provide services such as friendly and positive reminders, behavior tracking, progress monitoring or how-to information (Fishbach & Hofmann, 2015). All these apps are meant to be an aid to the behavior change process and help repeat the desired behaviors pass the first critical stages (Fishbach & Hofmann, 2015).

Nonetheless, on the other end of the physically active spectrum, there are people who are physically athletic by choice. Research in habits and behavioral change has shown that people who are currently physically active are significantly more likely to keep themselves consistent with their current activities (Aarts, Paulussen & Schaalma, 1997). Because for these individuals, after having repeated their behaviors for long enough, their PA habits have reached the line of automaticity (Lally et al., 2010). In other words, they already become a part of their routine, which is rather easier done than skipped. Thus, we hypothesized that physically active people may not need help or support coming from the nudges.

Hypothesis 2: General level of physical activity moderates the positive relationship between self-initiated nudging and physical activity. This relationship is stronger for individuals who are generally low (vs. high) on physical activity.

Another factor that could leave an impact the effectiveness of the nudges is the organizational exercise climate (OEC). Earlier research has shown that organizational climate could influence employee's health behavior (Mearns, Hope, Ford, & Tetrick, 2010). Engaging in physical exercise alone is not easy, and in an unsupportive exercise climate at work, would further undermine the employees' attempts to prioritize their health or lead a healthy lifestyle (Sonnentag & Pundt, 2016). Unsupportive exercise climate could therefore also dampen the nudges' effectiveness, because people are more inclined to defer physical activity and ignore their nudges.

Fortunately, in more and more organizations and companies, there is increasing awareness of the sedentary problems and have invested millions to tackle the physical inactivity problem among their employees (Cawley, 2014). Several companies and offices have adopted posters such as "Elevate your health. Dare to take the stairs!" (Kerr, Yore, Ham, & Dietz, 2004; Andersen, Franckowiak, Snyder, Bartlett, & Fontaine, 1998). Some companies include build a break room; at some organizations, there is a designated exercise space in the office with yoga mats, jump ropes, or dumbbells (Dishman, Oldenburg, O'Neal & Shephard, 1998). Some companies, in the USA, Germany, Norway and The Netherlands even provide their employees to a fitness center as a part of their labor contract (Cawley, 2014). When there is a high degree of exercise encouragement from the workplace, it lets employees know that their health is also a priority of the organization (Sonnentag & Pundt, 2016). Thus, it would have a reassuring effect, which could strengthen with the employees' determination to engage in some form of physical activity, and they may be less likely to disregard their nudges when they are reminded. Thus, OEC could play a role in transferring nudges into actual activities.

Hypothesis 3: The OEC has a moderating effect on the positive relationship between self-initiated nudging and physical activity. This relationship is stronger in organizational climates that encourage exercise (vs. not).

Daily physical activities and daily workplace energy, mental health and job performance

Earlier, we have described the multitude range of long-term benefits that comes with frequent physical activity or exercising. We push forward that it would not have to stop there. There are also immediate benefits that come with exercising that both infrequent and veteran exercisers can attest.

Regardless of the intensity level, physical activity or exercising is known for its invigorating effects (Faulkner & Taylor, 2005). Studies have shown that people feel better and more energetic following an exercise session (Bassuk, Church & Manson, 2013). Besides, regular physical activity can improve muscle strength and boost endurance. Physical activity delivers oxygen and nutrients to the tissues and helps cardiovascular system work more efficiently. Thus, when the heart and lung functions improve, employees could have more energy to tackle daily tasks (Bassuk et al., 2013).

Hypothesis 4a: Daily physical activity is positively related to self-reported workplace energy.

Not only just boosting energy, physical activity, even if it is not intense, was associated with lower levels of depression (Brosse, Sheets, Lett & Blumenthal, 2002). As short as 20 minutes of aerobic exercise was found to boost one's mood. A study on college students found that

regardless of intensity, all exercisers reported to have and significant post-mood benefits (Ekeland, Heian, Hagen, Abbott & Nordheim, 2004). In addition, even a short walk was seen to improve overall mood (Bassuk et al., 2013; Faulkner & Taylor, 2005).

Hypothesis 4b: Daily physical activity is positively related to workplace mental health.

Finally, physical activity also leads to sharper mental focus. Research found that participants who completed a short stationary cycling exercise had faster reaction times on working memory tasks immediately after the exercise. This could mean that short bouts of cardiovascular exercise may enhance the brain's ability to allocate attentional and memory resources, thereby supporting executive functioning (Hogan, Mata & Carstensen, 2013). We, therefore, believed this might have major implication towards better work performance.

Hypothesis 4c: Daily physical activity level is positively related to job performance.

All four hypotheses are depicted in the proposed employees' health behavior model (figure 1).

The study as a whole consists of two phases, the nudge item generation and the diary study. The main objective of the first phase is to compile a comprehensive scale of nudge items that people frequently use in their daily life, without being too overly exhaustive. This scale will allow us to thoroughly examine the self-initiated nudging construct and its relationship with PAs in the diary study (phase 2).

Nudge Items Generation

The nudge items were created in two stages, gathering nudge items and items selection.

Using structured interview method (see questions in table 1), we gathered data from 107 people from all parts of the PA spectrum, ranging from not very active to very athletic (i.e., one time or less per week to 6 or more times per week). 57.7% of the participants were female. In addition to the survey, a systematic article search was conducted to see if any self-initiated nudges were empirically studied, using psychINFO, PubMed and Google Scholar. The keywords used were: 'self-imposed nudging", "self-initiated nudging", "self-nudging and health-related habits", "reminder apps use and exercise".

At the end of this stage, we scanned all the nudges that we gathered through interviewing and web search using Atlas.ti software. Nudges that are similar in content were reduced into one item. After this process, a list of 37 non-repetitive nudges was generated, with the items were separated into the aforementioned mechanisms (See appendix B).

In a next step, we tried to condense the list, by making the items more general, because 37 items would make a rather long scale and some of the items were very specific. A final list of thirteen broader nudges was created at the end of this nudge items generation phase (see table 2).

Method

Participants

Participants were recruited from two online real-estate offices, using a contact person in each office – the office's (HR) manager. A total number of 71 employees were initially asked to participate. All participants were either part of an international group from a Netherlands-based office, or from another office from Australia. All participants indicated that they have a good command of the English language. The final sample consists of 41 persons who answered the diary for at least three days (57.74% retention rate). The mean age of the participants was 31.46 (SD = 9.40), and 56.1% of the sample was male. For marital status, more than one-third of the participant had no partner; 22% lived with a partner with no children; 22% lived with a partner and had children; 9.8% were single parents, and the rest indicated they still live with their parents or 'other'. Of all participants, 7.3% completed a technical school education; 41.5% held a technological institution degree; 36.6% finished their university, and 14.6% attended post-graduate studies or above.

Participants were mostly full-time employees, with one exception who indicated a project-based contract. The employees worked on average 41 hours per week (SD = 2.65), with 48.8% indicated they worked with information, 46.3% worked with people and 4.9% worked with things or other tasks. Lastly, 90.2% indicated their physical activity pattern at work as 'sitting and light work', the rest answered that their pattern was mostly 'standing and light' work.

Materials

The general questionnaire.

Organizational exercise climate. This questionnaire was taken from a two-part questionnaire Organizational Health Behavior Climate, which is aimed at measuring the perception of employees on how much the workplace encourages healthy eating and exercise habits (Sonnentag & Pundt, 2016). This part uses a 5-point Likert scale, ranging from 1 = "I do not agree at all" to 5 = "I fully agree". The questionnaire contains three subscales that reflect the three levels of both tangible and intangible support towards exercising: (1) values and expectations, (2) organizational practice and (3) communication. Values and expectation subscale includes items such as "Exercise and physical activity for employees are considered by the management to be important in this organization". One example from the organizational practice

subscale is “Employees from this organization pay reduced fees in fitness centers”. Lastly, communication subscale comprises items such as “Here, one talks openly with colleagues about how to stay healthy by exercising”. The score of each participant could be simply calculated for each subscale or aggregated into one summed score, to indicate how supportive the work environment is on the support-unsupportive continuum. For internal consistency, the Cronbach’s α indicates an acceptable level, with Cronbach’s α of all the subscales are around .81.

The physical activity general questionnaire. This is the adapted version of the International Physical Activity Questionnaire (IPAQ). This general questionnaire is used to establish the basal physical activity pattern of the employees, which can be used later to as a between-person factor. Our version comprises thirteen statements, such as “I am physically active” or “I do vigorous physical activities”. There were also two items that were used to measure how the participants enjoyed and were being satisfied with their physical activity level: “Today, I enjoyed being physically active” and “Today, I was satisfied with my physical activity level”. The questionnaire uses a 5-point Likert scale. For the qualitative statements such as “I am physically active”, the scale ranges from 1 = ‘never’ to 5 = “very often”. For quantifiable statements such as “I do vigorous physical activities”, the scale is as follows: 1 = 0 session, 2 = 1,2 sessions/week, 3 = 3 sessions/week, 4 = or 4,5 sessions/week, 5 = 6 or more sessions/ week. Overall, the scale has a good level of internal consistency, reaching approximately .87 in this study.

General mental health. General mental health is measured by the General Health Questionnaire (GHQ-12), which is a screening device for identifying minor mental complaints in the general population. Overall, the scale has a good level of internal consistency, reaching approximately .89 in this study. For the scoring, we used a 7-point Likert scale that ranges from 1=”completely disagree” to 7 = “completely agree”. This scale was used as a control variable when testing the relationship between daily PAs and workplace mental health (hypothesis 4b).

The diary.

Self-initiated nudging. As mentioned in the item generating section, the list comprises 13 common nudges that could be implemented during the office hours. Some examples from the nudge list are “My smartphone reminded me of physical activity goals throughout the workday,” and “Today at work, I reminded myself to walk or use the stairs”. Participants were asked to rate themselves on how much they had used the nudges on a 7-point Likert scale, which ranges from 1 – “strongly disagree” to 7- “strongly agree”.

The daily physical activity questionnaire. This questionnaire has the same format with the general questionnaire. However, the scale was adjusted and framed to suit the daily level. A

few examples from the of physical activity at work items are “Today at work, I moved around a lot” and “Today at work, I used the stairs”. An example of physical activity outside of work is “Today, I did vigorous physical activities”. The scale at the general level has a Cronbach's alpha α =. 84. Besides, we asked the participants to estimate their time spending on sitting, moderate and vigorous activities with three questions: “How many minutes in total did you spend on sitting today?”, “How many minutes in total did you spend on moderate physical activities today?” and “How many minutes in total did you spend on vigorous physical activities today?”

Energy level. The energy level is measured by a 5-item questionnaire which was adapted from the Shirom-Melamed Vigor Measure. The scale was designed so that participants could rate themselves on their experienced energetic feelings during the work hours. Example items are “Today at work, I felt vigorous”, “Today at work, I felt energetic” and “Today at work, I felt I had physical strength”. All of the items are rated on a 7-Likert scale, ranging from 1 – “strongly disagree” to 7- “strongly agree”. The general-level Cronbach's alpha of the workplace energy scale is α = .83.

Workplace mental health. Daily health was measured by a day-level adaptation of the *General Health Questionnaire-12 (GHQ-12).* The scoring format remained the same as the general level. However, the items were adjusted and rephrased to capture the employees’ mental health at the daily level. Example items are “Today at work, I felt constantly under stress” and “Today at work, I was capable of making decisions”. The general-level Cronbach's alpha of the daily mental health scale is α = .81.

Work performance scale. The work performance scale is a short, validated scale which was adapted the in-role and extra-role performance scales by Goodman and Svyantek (1999). The scale comprises three in-role items and three extra-role items. An example of the in-role item is “Today at work, I met all requirements of my position”. An extra-role example item is “Today at work, I helped colleagues who experienced high work pressure or other problems”. For both in-role and extra-role items, participants were asked to rate themselves on a 7-Likert scale, 1 = not at all, 7 = totally. The scale on the general level has a Cronbach's alpha α = .82.

Procedure

This diary study phase consists of two stages. At the beginning of the study, the manager distributed a general intake questionnaire link among the employees. In this intake questionnaire, participants were asked to fill in a short questionnaire about their personal information, general physical activities, and their organizational exercise climate at the workplace and their general mental health.

Participants were then sent an email invitation to an online diary, where they were asked to log themselves every day for ten consecutive days, or two weeks of work days, about their actual performance of any physical activities, their use of nudges, level of energy, mental health and their work performance on that day. Participants who agreed to take part in this study logged in on average 6.3 days (SD = 1.60).

Factorial Validation of the Self-Initiated Nudging Scale

Our aim was to develop a reliable instrument that captures a wide range of self-nudging activities without an exhaustive list of items to be for it to be used conveniently. For this, we already scaled down the numbers of items to thirteen. However, before using the scores from the newly-developed 13-item self-initiated nudging scale in other analyses, we needed to assess its factorial validity. Firstly, the Cronbach's alpha of the 13-item self-initiated nudge scale was α = .81. We also calculated the Cronbach's alpha of the daily scale, with the coefficients of day 1 to day 10 ranging betwen α = .55 and α = .94 (see table 1). This was obtained by using the total general-level sample (N = 260) to calculate means and standard deviations of the items. Yet, as the scale was used in a nested design (days nested within participants), this was insufficient. In order to examine further the factorial validity of the nudge scale with thirteen items, we performed a multilevel exploratory factor analysis (MLEFA).

Multilevel exploratory factor analysis

We performed a multilevel varimax rotation on the nudge items at the first level (N = 260 occasions) and the individual participants at the second level (N = 41 participants). The goal is to examine whether a general factor representing "nudge use" exists, or the nudge items would load separately on different factors. If the latter scenario occurred, we would also explore whether the factors were related and could be extracted to a single nudge factor.

Using Mplus (Muthen & Muthen, 2004-2011), we performed a multilevel exploratory factor analysis (MLEFA) on the day- level nudge items, with varimax rotation. Given that we only have hypotheses concerning within-person variance, we left the between-person option as unrestricted. Starting with one factor model, the model indicated a misfit (CFI = .66, TLI = .55, SRMR within = .10). Thus, the case for the single nudge factor is rejected. Next, we explored the two-factor model. The fit indexes indicated a better fit, nonetheless with substantial cross-loadings, all most across all items (CFI = .87, TLI = .62, SRMR within = .06). The three-factor model seemed to be the best fit of all (CFI = .94, TLI = .84, SRMR within = .05). As for four-factor and five-factor models, the fit indexes became unstable, with either CFI or TLI was larger than 1. Thus, upon checking all the models, we believed that the three-factor model is the best fit.

After having checked the items contained in each factor, we found that the three-factor model had a theoretical basis. The first factor contained items 1, 2, 3, 4, 11 and 13, which have implications rather exclusively to the work-specific PA or PA at work, and thus were easier to be used in conjunction with one another. We named this factor self-initiated work-specific nudge, or work-specific nudge for short. The second factor contained items 5, 6, 7, which were fitness goal sharing, PA activity discussing and the adjustment of one's work to be physically active. We called this factor fitness-related socializing. The third factor comprised items 8, 9, 10 and 12, which were the digital reminding and tracking items, together with a self-motivating item that both were commonly used throughout the entire day, beyond just the time at work. This factor was named self-monitoring.

We found there were items that also slightly loaded on other factors, especially items in factor one. However, in the subsequent analysis, it was found that if all cross-loading items were removed, the fit indexes dropped. Hence, in order to check the fit level of the three-factor model, we decided to investigate it further, using multilevel confirmatory factor analysis.

Multilevel confirmatory factor analysis

We performed a multilevel confirmatory factor analysis (MLCFA) on all thirteen day-level items. As in the MLEFA, we only modeled the within covariance matrices. The results of the MLCFA, however, did not indicate a good fit (CFI = .68, TLI = .61, SRMR within = .029). Upon checking the standardized loadings, we found that each factor had quite a different range of loading. The first factor had within-level coefficients ranging from .41 to .66 (ps < .001). The second factor had the loadings range of .68 to .83 (ps < .001). The third factor's items loadings were from .60 to .73 (ps < .001). The three factors did not to form a second-order nudge factor (CFI = .66, TLI = .60, SRMR within = .034).

The problem seemed to lie behind the fact daily nudge is such a unique type of scale that could have tremendous different combinations over the course of the study, both within-individual and between individuals. Thus, we accepted that there would be reduced fit, if we tried to load them squarely on different factors. However, to enhance the fit of the model to a more acceptable level, we decided to exclude the cross-loading items (from the MLEFA) in factor 1 that had the lowest loadings. We chose two items which had the loadings of approximately .40, one item was "Today at work, I made sure that had fitness equipment in sight for a short exercise break ", and the other was "Today at work, I designed health cues for myself (e.g., running shoes in sight, hand weights on my desk)". These items were similar content-wise and they both seemed to not have very high loadings.

After removing those two items from factor 1, the factor loadings of the items in factor 1 then ranged from .50 to .66 (see table 3). The results of the MLCFA, indeed improved (CFI = .86, TLI = .69, SRMR within = .029). Nonetheless, the general level Cronbach's alpha of the 11-item scale dropped to α = .79, and Cronbach's alpha coefficients of the daily scale also dropped, ranging from α = .51 to α = .92. The three factors remained unconnected (CFI = .66, TLI = .63, SRMR within = .074).

Analysis strategy

After validating the scale using the two-level nested model with the nudge items (daily variables) at the first level (N = 260 occasions) and the individual participants at the second level (N = 41 participants), we continued to further our analyses using the same nested methodology. Again, the Mplus software (Muthen & Muthen, 2004-2011) was utilized to analyze our data. The predictor variable at the within-person level- daily self-initiated nudge factors- were centered to the individual mean, and so were daily levels of physical activity at work and outside of work. For the between-person level variables, general physical activity and OEC , we centered them using the grand mean function. The final within-person dependent variables, which were daily workplace mental health, energy and work performance, were also centered to the individual mean.

Our multilevel models could be tested as a series of regression equations. We started by testing the direct links between each of the daily nudge factors and each of the PA variables, at work and outside of work. With all within-person variables centered to individual means, we could test more precisely the relationships between the fluctuations of one variable and the other (Hypothesis 1). Next, we entered the two between-person independent variables (general level of physical activity and OEC). We could then investigate the cross-level interactions with each of the between-person variable separately (Hypothesis 2 & 3). Finally, we entered the three other daily outcome variables (workplace energy, mental health and work performance). We proceeded to test the direct links between different PAs and the three variables (Hypothesis 1). For the workplace mental health variable, the general mental health score from the initial intake questionnaire would be used as the control variable.

Results

Table 4 shows the means, standard deviations, reliabilities, intraclass correlations (ICC1), and correlations among the study variables at the within-person and between-person levels of analysis. ICC1 reflects the ratio of the between-person variance and the total variance. The low ICC1 value indicates the high within-person variance in the day-level variable. The results showed that 87% of the variance in daily physical activity at work, 74% of the variance in daily extra-role

job performance, 73% of the variance in daily in-role work performance, 49% of the variance in daily workplace mental health, 38 % of the variance in physical activity outside of work and 32% of the variance in workplace energy were explained by within-person differences. Thus, the optimal analyzing methodology was our multilevel approach.

In addition, pertaining to quantifiable measurement of PAs, the majority of variance in daily total time spent on vigorous and moderate was explained by physical activity outside of work (75% and 55%, respectively). The daily enjoyment and satisfaction with one's physical activity score was found to be highly correlated with PA outside of work (r =.79, $p < .001$). Unlike the times spent doing physical activities, this variable would not add much to our later analyses, and we thus excluded this variable. Total time spent sitting significantly correlated with PA outside of work (r = -.38, $p < .01$), and only marginally with PA at work (r = -.17, $p < .10$).

Effectiveness of different nudge factors

Regarding hypothesis 1, we examined the specific relationship between each of the three nudge factors on (a) self-reported physical activity at work (b) self-reported physical activity outside of work. As indicated by Model 1, 2 and 3 in Table 5, both specific work nudge factor, fitness-related socializing as well as self-monitoring factors were positively related to PA at work, with, y = .84, $p < .001$, y = .49, $p < .001$ and y = .44, $p < .001$, respectively.

Fitness-related socializing factor was also found to be predictive of PA outside of work (y = .10, $p < .05$), while self-monitoring factor was only found to be approaching marginal significance, y = .05, $p = .054$ (Model 1,2 and 3 in Table 6). Nonetheless, it was enough to confirm the effectiveness of all self-initiated nudge factors. All in all, we have enough evidence to claim that indeed daily nudge use was predictive of self-report PAs, and thus confirmed hypothesis 1.

Further, we also explored the links between self-nudging and the time spent on different activities. It was found that both factors above were also good predictors of the time spent doing vigorous activity, although fitness-related socializing factor was found to be seemingly stronger, with y = 3.00, $p < .001$ and y = 2.14, $p < .05$. This means each incremental score in former factor predicted *three* additional minutes of vigorous activity and each incremental score in latter factor predicted *two* additional minutes. They were, however, unrelated to either time spend doing moderate activity, y = .51 and y = .13, *ps* > .10, or sitting, y = 10.77 and y = 6.32, *ps* > .05.

General level of physical activity and its effects on the nudge's effectiveness

To test Hypothesis 2, we tested the cross-level interaction effects of the between-person general level of physical activity and the three within-person nudge factors on (a) daily physical activity at work (b) daily physical activity outside of work. Given that we found three significant

effects from the simple multilevel regression analyses with PA at work and two with PA non-work, we tested three moderation models for PA at work and two for Pa non-work. As shown in table 4, models 4, 5 and 6, general level of physical activity did not moderate the relationships between any of the nudge factors and physical activity at work. For physical activity non-work, general physical activity indeed moderated the relationships between physical activity non-work and both fitness-related socializing, as well as self-monitoring factors, y = -.13 and y = -.09, *p*s < .05, respectively (see table 6, model 4 and 5). Hypothesis 2 was therefore partly confirmed.

In order to further examine each we conducted simple slope tests for the four groups (figure 2 and 3). When the general level of activity was higher (group 3 and 4), the relationship between fitness-related socializing nudge and PA non-work was not significant (βs = .01, $p < .05$), whereas when the general level of activity very low (group 1), fitness-related socializing nudge was significantly and positively related to PA non-work (β = .09, $p < .05$). Group 2 (moderate level) seemed to benefit the most from this type of nudge, β = .17, $p < .01$.

The same analysis was conducted for the self-monitoring factor. However, there was a slightly different pattern for this group. Both high and low general physical activity groups did not benefit from this type of nudge, βs = .02 and β = .03, *p*s > .05. Group 2, again, benefited the most from this type of nudge, β = .13, $p < .01$.

Organizational Exercise Climate and its effects on the nudge's effectiveness

To test Hypothesis 3, we tested the cross-level interaction effects of the between-person OEC and the three within-person nudge factors on (a) daily physical activity at work (b) daily physical activity outside of work. The same steps as for hypothesis 2 were carried out.

As shown in table 5, models 7, 8 and 9, OEC did not moderate the relationships between any of the nudge factors and physical activity at work. The same pattern was seen for activity non-work, where the OEC did not influence the relationships between any of the nudge factors and physical activity at work (see table 6, model 6 and 7). Hypothesis 3 was not confirmed.

Daily physical activity and daily workplace energy, workplace mental health and work performance

In hypothesis 4, we were interested in the links between daily physical activity and the three work-related outcomes. We tested physical activity at work and physical activity outside of work in two separate analyses.

PA at work was found to be a significant predictor of daily workplace energy, y = .19, p < .05. Interestingly, PA at work was also found to be a significant positive predictor of daily

workplace health (controlled for general mental health), albeit negatively, y = -.13, p < .05. PA at work did not predict daily work performance, either in-role or extra-role, y = -.05 and y = -.02, *p*s > .05. In an exploratory analysis, we tested the indirect links between the three nudge factors to daily workplace energy and work health via daily PA at work. Nonetheless, all six mediation models showed to have non-significant beta values (βs ranged from .01 to .06, *ps* > .05).

PA outside of work was also found to be a significant predictor of daily workplace energy, y = .1, *p* < .05. Hypothesis 4a was confirmed. PA outside of work did predict daily workplace mental health (controlled for general mental health), y = .10, *p* <.05, but not work performance, either in-role or extra-role, y = .04, y = -.04 and y = -.02, *p*s > .05. Hypothesis 4b was hence partly confirmed, but hypothesis 4c was not. Further, we tested four mediation models with two significant nudge factors (fitness-related socializing, self-monitoring factor) with daily workplace energy and daily mental health via PA non-work. All models failed to yield significant results, β = 0.03 and β = 0.01, *p*s > .05, for fitness-related socializing factor, and β = 0.02 and β = 0.01, *p*s > .05, for self-monitoring factor.

Discussion

In this study, we introduced self-initiated nudging as individually purposeful goal-oriented behavior that is aimed at giving the users an increased probability that they will perform their (desired) physical activities. We developed a reliable scale to measure self-initiated nudging, and the results of (multilevel) factor analyses provided support for a three-factor model at the day level. These findings suggest that people who wish to be more physically active could take advantage of a lot of different strategies, including workplace-specific strategies, sharing and discussing fitness aspirations, as well as digitally tracking and reminding themselves throughout the day. Of course, different strategies were shown to bring about different benefits. Workplace-specific strategies unsurprisingly only worked the for PA at work. Fitness-related socializing strategies worked for both PAs, while self-monitoring strategies worked better for PA at work, compared to PA outside of work.

Further, we found that in regards to PA at work, all three nudge factors's effectiveness were not moderated by how active a person generally was or how supportive the exercise climate of their workplace was. This means if someone's goal is to get some movement during their work, harnessing nudges may undoubtedly be beneficial, regardless of the OEC or the general level of physical activity.

Nonetheless, for PA outside of work, the effectiveness of the nudge factors was moderated by their general activity level, with people whose general level of activity was high did not benefit from all self-initiated nudging, while the moderately active group benefited from both fitness-related socializing and self-monitoring. People who were not very active only benefited from fitness-related socializing. OEC, again, did not moderate the nudge effectiveness of the nudge on PA outside of work.

Lastly, we explored the link between daily PAs and three work-related outcomes, including daily workplace energy, mental health at work and work performance, both in-role and extra-role. It was found that daily PAs did not influence work performance, yet were positively associated with how energetic someone felt at work. Interestingly, PA at work was found to have a negative association daily mental health at work, whereas PA outside had a positive association. Mediation models between self-nudging, to workplace mental health and energy via physical activities also were tested, yet none of them were found to be significant.

Theoretical implications

Throughout the whole study, there have been a few intriguing findings. First of all, we found that nudges work exceptionally well for PA at work, while only have a modest influence over PA non-work. There are a few possible explanations for these findings. Earlier, we found that most of the vigorous and moderate level of physical activity variance attributed to PA non-work, which means that PA at work is mostly light intensity and low-impact. Thus, it might not have required the same level of effort and is significantly easier to be carried out when an individual was notified (e.g., a short walk to the cafeteria or short staircase use is rather easier compared to jogging or walking on the staircase machine for an extended period of time). An alternative explanation is that workplace PA may not be as habitual and more spontaneous, compared to PA non-work. Less habitual and more spontaneous activities are generally more susceptible to irregular cues such as a nudge (Thaler & Sunstein, 2008).

Next, by further exploring the interaction effect of the nudges on different groups with varied levels general of physical activity, we found it was intriguing that fitness-related socializing worked well for both moderate and not very active group, whereas self-monitoring only benefited the moderately actively group, but did not help those who were not very physically active. We had expected that this would be the group for which nudges would have assisted the most. Nonetheless, this coincides with a finding by Stawarz et al. (2015), where she and colleagues discovered smartphone reminding or tracking apps did not seem to help beginners establish their exercise

habits. Stawarz et al. (2015) explained that while cues from the digital devices have the potential to help, most of them do not have optimal designs and are often too weak on their own.

In addition, we found that how an individual perceived the support for physical activity from their workplace did not moderate any relationship between the nudge factors and PAs, both at work and outside of work. This is rather exciting, as earlier research suggested that OEC may help with people's intentions to be physically active. One way that this happened is that the direct cross-level effect from OEC to daily PAs was considerably stronger, and thus overshadowed the interaction effects between it and the nudge factors. This is evident in table 6, where the magnitudes of the fixed between-person beta values of OEC were substantially bigger than the beta values of the interaction effects. Nevertheless, the perceived OEC was rather interwoven with the general level of PA to begin with (see table 4). It might be the case that posters, terms or interventions aimed increase employee's physical health are more salient for employees with a strong exercise identity, whereas lesser active employees are not attentive to these cues and messages (Sonnentag & Pundt, 2016).

Moreover, it was very counterintuitive to find that daily PA at work was negatively associated with mental health at work. Although PA at work and leisure time PA are very different, with most of the major benefits were attributed to leisure time PA, certainly not much has been said about the negative consequences of the doing bodily movement at work, especially with our office worker sample. One of the most logical explanations for this finding could be that when individuals were having a hard day at work, they are more inclined to take more breaks to stand up, do stretches, going for a walk or to get a coffee (Henning et al., 1997). Taking breaks at work was found to be a recovery strategy, which helps reduce stress and maintain performance (Demerouti et al., 2012; Tucker, 2003). The nudges hereby might have happened to help with the actualization of the activities.

Lastly, we did not find any support for the link between daily PAs and daily work performance. This may not be surprising, as it has been found that most benefits associated with PAs can only be reaped after a certain period of time (Warburton, Nicol & Bredin, 2006). Our findings suggest that it could be the case for work performance. Depicted in table 4, there were significant correlations between the general level of physical activity and work performance, both in-role and extra-role. Hence, daily PA might still have contributed to better work performance, nevertheless, in an accumulative fashion.

Theoretical contributions

Our research on nudges as a means of boosting PAs may make an important contribution to the literature. Much of the literature work on how to encourage PAs has been about either top-down approach, such as putting more willpower to stick to a routine, or complete bottom up approaches, such as having other nudges from a third party imposed upon them. Self-initiated nudges, which are a combination of purposeful top-down behaviors, yet mostly impact an individual via bottom-up mechanisms. This study helps to bridge the gap between nudging, habit and behavior change literature, with comprehensive implications for employees' well-being.

Our study is not only among the first to have developed a reliable scale to measure self-nudging on the daily level, but also empirically demonstrate how self-initiated nudges can be grouped together on a daily basis. Theoretical framework from Thaler & Sunstein (2008), as well as Ly et al. (2013) only group the nudge via their mechanisms. In this study, we found that self-initiated nudges should be first grouped through their range of effectiveness (e.g., only at work or throughout the day), and then further into different mechanism (e.g., fitness-related socializing and self-monitoring).

Secondly, we found support for the criterion validity of the daily nudge scale, in line with our expectations. Each of the nudge factors was able to reliably predict PA at work, while two of them also showed associations with PA non-work. This could be a good complement to other methods used in behavioral change and motivation research, such as intrinsic and extrinsic motivation scales in self-determination theory, to have a higher overall predictive power towards PAs (Teixeira, Carraça, Markland, Silva & Ryan, 2012). Besides, most of the studies in PAs have used retrospective methods, for which our daily diary method could give a new perspective.

Limitations and Future Research

However, the present research is not without limitations. First and foremost, we did not take into account other confounding factors as were mentioned by the participants. For example, a feedback from a participant mentioned that work pressure may be a hindering factor. This could be the case, because although all participants came from similar offices and worked in the same sector, their levels of responsibility and the amount of tasks are not equal. This could potentially hinder their intentions to carry out their physical activities, especially on the day when there is a great pressure to finish their tasks. Another group of participants said that family obligations were also something they had to overcome if they would like to stay physically active. Future studies, therefore, could expand our model to incorporate those factors to capture a more complete picture of nudge and physical activity.

Second, we cannot infer definitive causal links from some of the relationships that we have found, given the correlational nature of the study. That is, the findings in this current study cannot postulate whether self-nudging results in more physical activities and that translates into work-related outcomes. However, we deem it logically reasonable and to assume that the daily use of self-initiated nudging brings about the changes in physical activities on that day, since the opposite direction does not seem to be very plausible on the day level. Nonetheless, the same cannot be said for daily leisure PA and work-related outcomes, since most people who engage in leisure PA do them after the work-time, and thus leisure PA cannot result in those outcomes. Future research could investigate the efficacy of the nudge experimentally, and use a lagged time series model to infer the causal effect from PA outside of work from the previous day.

Another limitation is we were not able to test for combined efficacy, which are the effect when different nudge factors are combined together. Given the limited collected data entries of our study, we quickly ran into the negative model parameter problem when a cross-level moderator was entered into the multiple regression equations. However, as our scale was newly developed, and the three factors did not form a second-order construct, it was of better interests to see the full specific effect of each factor and how they interacted with the other between-level constructs. Nonetheless, oftentimes individuals would create several nudges simultaneously for themselves that stem from different factors. Future studies may benefit from having a larger data set to test the complete model, using a moderated mediation procedure on top of cross-level multiple analyses.

Finally, we used a geographically varied sample, with both Dutch and international participants from offices in The Netherlands and Australia, which may enhance the generalizability of our findings. However, they were homogeneous in terms of industries and professions. That means some of the sample characteristics from this sample may have been less representative of the entire workforce. Even so, we argue that other workers from all industries and occupations may use nudges to help with their daily physical activities, since nudges come in many shapes and forms that can be adopted and personalized to fit the need of every person.

Practical implications

This research may shed light on the efficacy of small adjustments such as a nudge, and how individuals could proactively use them to improve their physical activity. Individuals who often sit long at work could make use of various nudges to be a bit more active, from written notes, to digital reminders and having a fitness-related social group. The same can be said those who want to take part in recreational exercise, where nudges can also come in handy. Yet, for those are

not very active and want to start making leisure-time exercise a habit, a supportive social circle where they can share or discuss fitness goals together should be the basis.

In addition, the findings related to the perceived OEC may suggest that people with different physical activity levels may perceive OEC differently. Thus, if organizations do care about the physical fitness of their employees, they should also make an effort to target individuals that are less active. They may potentially benefit later from a more energetic, mentally healthy and higher-performing workforce.

Conclusion

Committing to be physically active is an uphill battle, especially for office employees, when being sedentary has become a norm. Fortunately, the current findings suggest that self-nudging could help decision makers avoid biases and inconsistencies when it comes to physical activities. However, the effectiveness of the nudges may vary between different types, what they are applied to, and how active a person is to begin with. Besides, organizations can also contribute to promote employee physical activity. They could benefit from creating a climate in which employees are encouraged to have health-related goals and pursue them.

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Table 1

Structured interview to gather data to create the self-initiating nudge scale.

Interview questions
How physically active are you?
How many times per week do you participate in the activities?
Do you use anything such as reminders, helps or other supporting agents to increase the likelihood that they would carry out those activities?

Table 2

Items, means and standard deviations of the nudges on the daily level of the 13-item scale (N = *260 days).*

		M	SD
Day-level items			
1	Today at work, I purposefully made exercise part of my routine	4.27	.95
2	Today at work, I reminded myself to walk or use the stairs	4.43	.95
3	Today at work, I used reminders to be physically active	4.42	.98
4	Today at work, I made sure that had fitness equipment in sight for a short exercise break	3.87	.788
5	Today at work, I proactively talked about my fitness goal with others.	4.13	.86
6	Today at work, I proactively shared my physical activity with friends through social media.	4.15	.86
7	Today at work, I proactively adjusted my work so that I could be physically active	4.32	.80
8	My smartphone reminded me of physical activity goals throughout the workday.	4.33	.92
9	Today at work, I set up my smartphone to track my steps/activities.	4.22	.90
10	Today at work, I used wearable's (e.g., fitness tracker, smart watch) to track my physical activity	3.90	.6\9
11	Today at work, I actively monitored the benefits of physical exercise	4.02	.69
12	Today (at work), I motivated myself to be physically active	4.77	1.15
13	Today at work, I designed health cues for myself (e.g., running shoes in sight, hand weights on my desk)	3.74	.78

Note. Cronbach's alpha of the general scale was a = .81. Cronbach's alpha coefficients of the daily scale ranged from a = .55 to a = .94. Response options ranged from 1 *(completely disagree*) to 7 *(completely agree).*

Table 3

Factor loadings of each items from the finalized 11-item scale (N = *260 days).*

		Factor 1	Factor 2	Factor 3
Day-level items				
1	Today at work, I purposefully made exercise part of my routine	.50		
2	Today at work, I reminded myself to walk or use the stairs	.57		
3	Today at work, I used reminders to be physically active	.53		
4	Today at work, I proactively talked about my fitness goal with others.		.83	
5	Today at work, I proactively shared my physical activity with friends through social media.		.73	
6	Today at work, I proactively adjusted my work so that I could be physically active		.68	
7	My smartphone reminded me of physical activity goals throughout the workday.			.73
8	Today at work, I set up my smartphone to track my steps/activities.			.68
9	Today at work, I used wearable's (e.g., fitness tracker, smart watch) to track my physical activity			.60
10	Today at work, I actively monitored the benefits of physical exercise	.66		
11	Today (at work) I motivated myself to be physically active			.61

Note. Cronbach's alpha of the general scale dropped to a = .79. Cronbach's alpha coefficients of the daily scale ranged from a = .51 to a = .92.

Table 4

Descriptive statistics, within-person and between-person correlations among variables

	M	SD	ICC1	1	2	3	4	5	6	7	8	9	10	11
Between-person														
1. General level of physical activity	1.68	.92	-	-										
2. OEC	2.20	1.62	-	**	-									
Within-person														
3. Work-specific nudge	4.10	.86	.24	.065	.015	(.73)								
4. Fitness-related socializing nudge	4.20	.51	.35	.068	-.102	..34**	(.79)							
5. Work and beyond nudge	4.44	.64	.24	-.091	-.12	.38**	.35**	(.74)						
6. PA at work	3.24	.38	.13	-.10	-.09	.09*	.10*	.13*	(.78)					
7. PA outside work	3.00	.52	.62	.74**	.57**	..08	.13*	.21**	.08	9)				
8. Workplace energy	4.33	1.03	.69	.80**	.50**	.13	.18*	.16	.15*	*	(.61)			
9. Workplace mental health	4.74	0.63	.51	.70**	.40**	.11	.10*	.08	-.18*	*	.25**	(.68)		
10. Work performance intra-role	5.17	.74	.27	.46**	.21**	.02	.18*	.12*	-.04		.09	.25**	(.67)	
11. Work performance extra-role	4.84	.89	.26	29**	*02	.20*	.29*	.10*	-.01		.11*	.18**	.34**	(.71)

*p < .05; **p < .01

Table 5

Simple and interaction effects of the nudge factors, nudge factors and General level of PA, OEC on physical activity at work

	PA at work															
	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6		Model 7		Model 8		Model 9	
	Estimate	Se	Estimate	Se	Estimate	Se	Estimate	Se	Estimate	Se	Estimate	Se	Estimate	Se	Estimate	Se	Estimate	Se
Intercept	4.22	.75	4.22	.75	4.22	.75	3.34	.84	3.34	.16	3.22	.78	3.24	.74	3.37	.14	3.37	.14
Level 2 variables																		
General level of PA							-.07	.05	-.07	.1	-.07	.05						
OEC													-.07	.07	-.07	.05	-.07	.05
Level 1 variables																		
Work specific factor	.84***	.45					.30**	.21					.12*	.29				
Fitness-related Socializing factor			.44***	.04					.24**	.18					.34**	.14		
Self-monitoring factor					.49***	.05					.22**	.09					.10*	.05
Cross-level interaction																		
Work specific factor x General level of PA							-.03	.17										
Fitness-related Socializing factor x General level of PA									-.03	.11								
Self-monitoring factor x General level of PA											-.09	.06						
Self-monitoring factor x OEC													-.03	.17				
Fitness-related Socializing factor x OEC															-.02	.29		
Self-monitoring x OEC																	.01	.07
Variance Level 1 (within-person)	.06		.091		.01		.27		.28		.28		.27		.27		.28	
Variance Level 2 (between-person)	.05		.05		.04		.04		.04		.04		.04		.04		.04	
Model deviance	256.78		177.23		123.5		233.75		271.75		269.13		239.75		256.78		244.78	

*p < .05; **p < .01. ***p < .001.

Table 6.
Simple and interaction effects of the nudge factors, nudge factors and General level of PA, OEC on physical activity outside of work.

	PA outside of work													
	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6		Model 7	
	Estimate	Se	Estimate	Se	Estimate	Se	Estimate	Se	Estimate	Se	Estimate	Se	Estimate	Se
Intercept	3.23	.05	3.23	.05	3.23	.05	1.11	.31	1.11	.20	.76	.38	.76	.38
Level 2 variables														
General level of PA							1.21**	.18	1.21**	.081				
OEC											11.02*	.019	11.02**	.019
Level 1 variables														
Work specific factor	-.10	.10												
Fitness-related Socializing factor			.1**	.04			.24**	.45			.16*	.30		
Self-monitoring factor					.05	.05			.05	.20			.05	.26
Cross-level interaction														
Fitness-related Socializing factor x General level of PA							-.13*	.11						
Self-monitoring factor x General level of PA									-.09*	.17				
Fitness-related Socializing factor x OEC											.02	.10		
Self-monitoring factor x OEC													-.01	.1
Variance Level 1 (within-person)	.28		.28		.28		.87		.81		.86		.84	
Variance Level 2 (between-person)	.04		.04		.04		.18		.19		.10		.12	
Model deviance	256.78		177.23		123.5		271.75		269.13		291.13		244.78	

*p < .05; **p < .01. ***p < .001.

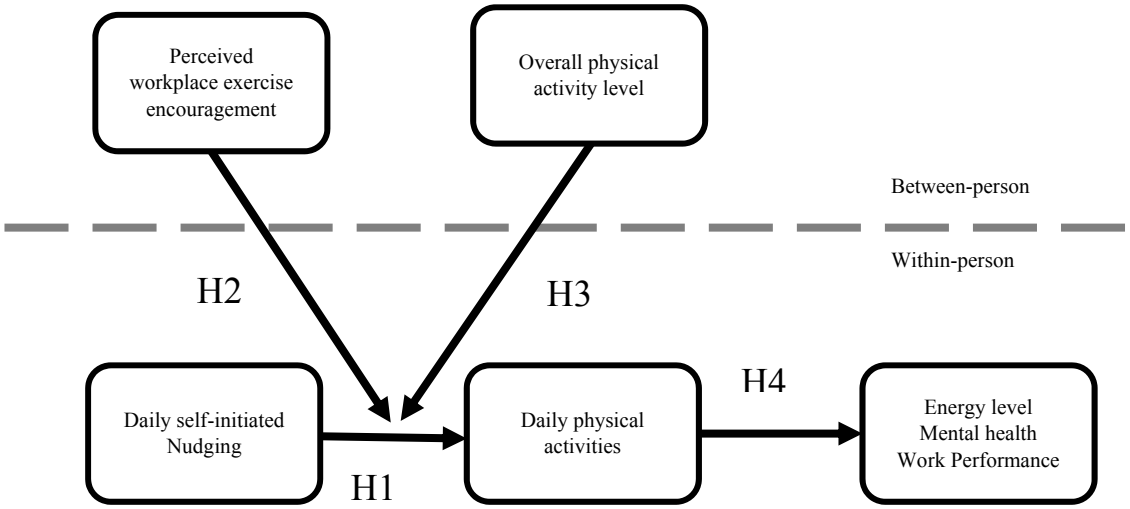

Figure 1. Proposed Employees' Health Behavior Model

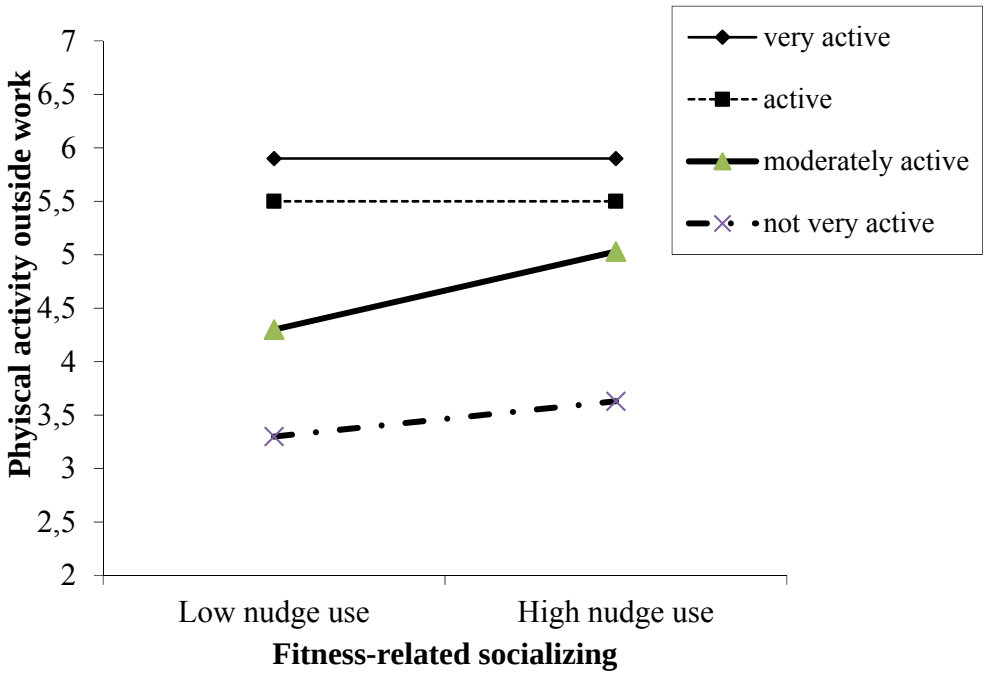

Figure 2. Simple interaction effect between fitness-related socializing factor and general level of physical activity.

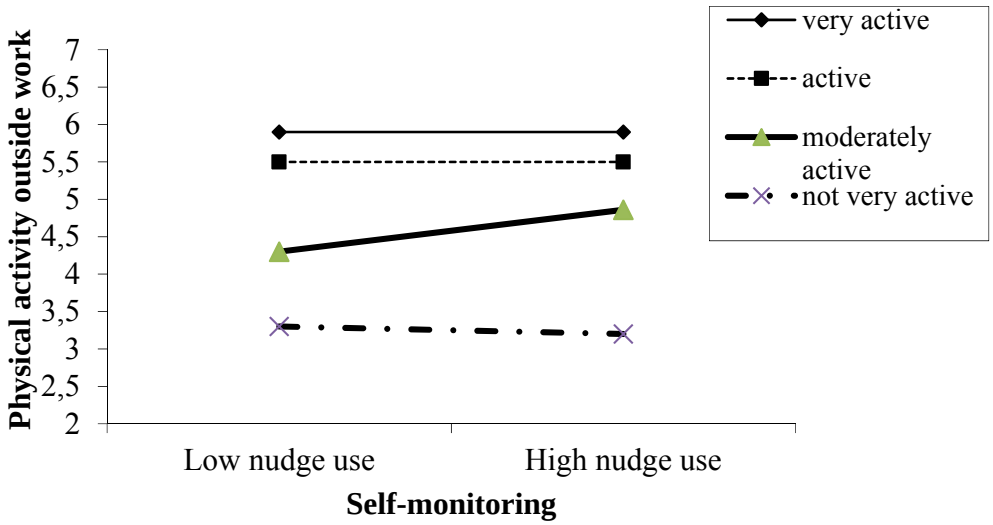

Figure 3. Simple interaction effect between self-monitoring factor and general level of physical activity

Appendix A

Theoretical nudge framework from Ly et al. (2013)

Table 7

Nudge taxonomy matrix

		MINDFUL		MINDLESS	
		ENCOURAGE	DISCOURAGE	ENCOURAGE	DISCOURAGE
ACTIVATING BEHAVIOURAL STANDARDS	EXPOSE	Salience, Reducing Required Effort	Salience, Increasing Required Effort	Herding, Defaults, Anchoring, Irrelevant Alternatives, Reputation, Framing, Identity, Salience, Emotion	Herding, Reputation, Framing, Moral Identity, Identity Salience, Emotion
	IMPOSE				
BOOSTING SELF-CONTROL	EXPOSE	Reducing Required Effort	Salience, Increasing Required Effort	Emotion, Herding	Emotion, Herding
	IMPOSE	Pre-commitment, Identity Salience, Reducing Required Effort	Pre-commitment, Identity Salience, Increasing Required Effort	Salience, Habit Formation, Mental Accounting, Emotion	Salience, Habit Formation, Partitioning, Emotion

Table 8

Examples of nudges for each category of the taxonomy

		MINDFUL		MINDLESS	
		ENCOURAGE	DISCOURAGE	ENCOURAGE	DISCOURAGE
ACTIVATING A DESIRED BEHAVIOUR	EXTERNALLY-IMPOSED	Simplifying tax rules to make tax filing easier.	Placing signs to remind people not to litter.	Advertising that most people are recycling to increase recycling efforts.	Using fake speed bumps to discourage speeding[9].
BOOSTING SELF-CONTROL	EXTERNALLY-IMPOSED	Simplifying application processes for college grants to encourage higher-level education[10].	Installing car dashboards that track mileage to reduce gas usage[11].	Automatically enrolling for prescription refills to encourage taking medication.	Placing unhealthy foods in harder to reach places[12].
	SELF-IMPOSED	Maintaining an exercise routine by agreeing to pay a small penalty if a gym session is missed[13].	Avoiding drunk driving by hiring a limo service beforehand[14].	Joining a peer savings group to encourage saving money[15].	Channelling money into a separate account to reduce the likelihood of it being spent[16].

Appendix B

The 37-item nudge list

Mindless Nudges

Default

1. I used the bike or walk as the means of transport.

2. I have made exercise as part of my routine I reminded myself about that.
3. When I went for a cup of coffee at work, I reminded myself to walk or use the stairs.
4. I exercised a little when I had to wait for something during the day.
5. I reminded myself to exercise first thing in the morning so that I do not find excuses not to do it later.

Framing

6. I reminded myself I am a step further away from my fitness goal if I do not take action today.

(Changing) Environment

7. I placed my favorite fitness inspirational quotes or images in the proximity of my workplace, and I looked or read it a few times today.
8. I had some fitness equipment in sight for a short exercise break.
9. I had my running shoes with me in case I need it.
10. I avoided walking towards the elevator if I can use the staircases.

Social Influence

11. I talked about my fitness goal with others.
12. I shared or update my current successes with friends through posts and tweets.
13. I compared activity level of myself to the more fit/healthy person in my social circle or someone I admired for his/her fitness level.
14. I competed with my friends in a fun way on some fitness goal.
15. I hanged out with people who have similar fitness goals.
16. I asked experts for help in certain fitness area.
17. I watched fitness motivational videos to help set the mood.
18. I reminded myself the consequences of those who are physically inactive.
19. I reminded myself all the benefits of those who are fit/physically active.

Mindful Nudges

Eliminate Boundaries

20. I parked my car a little further so I could walk.
21. I chose the route that passes by my health club/ gym.
22. I packed my exercise/gym clothes with me.
23. I anticipated the challenges I have to exercise, and made a commitment to go through in case those obstacles arise.
24. I had an appointment with a fitness partner to keep me accountable.

Chunking

25. I divided my physical activity into different chunks that I could easily complete and told myself to at least finish one chunk.
26. I gave myself a (verbal) reward/ acknowledgement when I finished something related to my fitness goal.

Alert & Reminder

27. I set an alarm on my computer to let me know how long I have been working and whether I should take break.
28. I used an app that pops up a health fact about inactivity at certain interval.
29. When I felt like I sit for too long, I use this as a sign to walk and exercise.

Progress Monitoring

30. I set a specific fitness goal for today that I need to complete.
31. I had a detailed plan of the exercises I would do today.
32. I programmed my smartphone to remind me of physical activity goals throughout the day.
33. I used reminders to be physically active.
34. I used my smartphone to track my remaining steps/activities for the day.
35. I rewarded myself when I achieved a fitness goal (e.g, personal record).
36. I inflicted some kind of punishment (e.g., no desserts) to myself if I skipped the exercise.
37. I kept monitoring the benefits of physical exercise (increased fitness capacity, reduced heart rate, under control weight, better mood, etc.).