JUST IN TIME ADAPTIVE INTERVENTIONS. CAN SMARTPHONES MAKE OFFICE WORKERS MORE PHYSICALLY ACTIVE?

THE NOVO NORDISK CASE

by

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INTRODUCTION

The primary objective of this thesis is to design JITAI Walk, a Just In Time Adaptive Intervention (JITAI) in order to improve physical activity (PA) in a working environment which widely differs from controlled laboratory settings.

The majority of adult time is spent in a sedentary behavior, especially sitting (1).

One of the main reasons for sitting is the work performed in office by “knowledge workers” also known as “white collars”. Knowledge workers spend majority of their time working is sitting position and this has been shown to be deleterious for health (2), even though leisure time is spent active enough to fulfill international guidelines. (3)

The experiment is carried out in collaboration with a department of a Danish, well known pharmaceutical company, Novo Nordisk A/S.

A group of 21 employees agreed to be part of the JITAI Walk.

Results have shown that JITAI Walk made possible to increase physical activity during working time by designing a JITAI. An important component of the intervention is the design of the mobile application and its activity notification.

In fact, as shown in JITAI Walk, notifications sent on specified conditions, not only make workers aware of their activity levels, but also increase awareness of the importance of being physically active throughout the day.

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A kiss to my wife for being patient.

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1.1. DEFINITION OF SEDENTARY BEHAVIOR

The definition of sedentary behavior finds its root in the Latin word "*sedere"* which literally means, "to sit". This behavior is characterized of having a sitting body position; it can happen during several different activities such as going out with friends for playing table games, commuting during a trip, working or just having leisure time spent watching television.

For a more appropriate definition of sedentary behavior, the concept of MET has to be introduced. MET is the unit of measure for energy expenditure. (1)

MET is defined as "Metabolic Equivalent" and it's a physiological measure that expresses the energy cost of physical activities and is defined as the ratio of metabolic rate during a specific physical activity to a reference metabolic rate. By definition:

$$1\ \mathrm{MET} = 1\frac{\mathrm{kcal}}{\mathrm{kg} * h} = 4.184\frac{\mathrm{kJ}}{\mathrm{kg} * h} = 1.1622222...\frac{\mathrm{W}}{\mathrm{kg}}$$

Sedentary behavior is defined as performing physical activity with energy expenditure of 1.0 - 1.5 MET (1). Examples of sedentary activities are watching TV, working at the workstation or commuting by car.

As opposite, active behavior is defined as having physical activity level in the range of 3 to 8 METs (1). Typical examples are sports such as cycling, walking/running or swimming. Finally, light intensity activities are defined by an energy expenditure of maximum 2.9 METs.(1)

1.2. CAUSES FOR SEDENTARY BEHAVIOR

Are now shown the main causes for sedentary behavior found in literature.

TV watching is a recurrent reason for sedentary behavior. Data from the "Health Professional Follow Up" demonstrated that increasing the amount of TV watching during leisure time has a strong association with weight gain and this relation is not dependent of exercise level or dietary choices. (6)

In the young population, increase in watching TV was positively related with decrease in physical activity. The more children aged the more the relationship between the two indicators became stronger. The range between age 6 and 7 could be critical for changes in BMI for children watching TV and/or playing computer game.

Behavioral change leading to spend less time watching television and more time doing physical activity might prevent obesity among children (7).

Concerning the adult population, sedentary behavior such as sitting is so widely spread that sitting has been defined as the new smoking. (34)

Of course, sitting or being active depends on the type of job. In fact, in the adult population, the occupation has been found having an effect in the determination of physical activity level. (3)

Sitting at a desk every day can lead to muscuskeletal disorder, chronic diseases such as obesity and type-2 diabetes and cancer. (36)(37)(38)(39)

In regard to European population, it has been seen that higher body weight is associated with lack of physical activity in adults and literature has pointed out that a reduction in energy expenditure during leisure time might be the trigger for obesity on large scale. (5)

So, in broader terms, sedentary behavior is triggered by inactivity due on choices of the individual, for example spending leisure time on the couch watching TV, or due to the nature of the occupation, for example, office workers are prone to spend more time sitting in front of their computers compared to physical workers.

Now that some major root causes have been identified, it is important to understand why sedentary behavior is unhealthy for the human organism.

1.3. PHISIOLOGICAL IMPLICATIONS OF SEDENTARY BEHAVIOR

After taking into account the totality of weekly physical activities such as walking, climbing stairs and play sports, the Harvard Alumni Study has concluded that men with an energy expenditure less than 2000 Kcal/week, had a 31% higher risk of death when compared with more active men. (2)

Metabolic dysfunction is one of the demonstrated consequences of sedentary behavior, it is characterized by decreased levels of cholesterol (High Density Cholesterol), increased levels of triglyceride and decreased sensitivity to insulin. (8)

Concerning bone health, it has been shown that physical inactivity leads to increase in bone resorption without contemporary changes in bone formation, which results in a reduction of mineral content in bones and may lead to osteoporosis. (10)

A profound effect of being physically inactive can be noted at cardiovascular level.

In fact, physical inactivity is a major cause of predisposition to cardiovascular disease, in particular ischemic heart disease (11). Moreover, available data suggests that ischemic heart disease and physical activity are inversely related and in a dose-response relation. (11)

When taking in account metabolic issues, diabetes comes quickly to mind. As seen previously, being physically inactive increase adiposity and might result in obesity, which is strictly associated with type 2 diabetes (45).

1.4. HOW MUCH DOES PHYSICAL INACTIVITY COST?

Reducing physical inactivity is not only a matter of increasing quality of life but also reducing the economic burden of the negative effects of a sedentary lifestyle.

The economic burden of sedentary behavior was calculated to be around 54 billion euros of which around 13 billion was paid by the private sector, 10 million by the households and 31 billion by the public sector. (14)

Deaths related to physical inactivity led to loss in productivity for around $14 billion dollars and around 13 million disability adjusted life years. (15)

In Denmark, the annual net costs of the health care system related to physical inactivity are, DKK 2,883 million. The production loss corresponds to a saving in future consumption of DKK 4,240 million as a result of shortened lifetime. (39)

A difference between high and low-income countries exists and data suggests that the high income countries pay the cost of physical inactivity with direct money (healthcare costs and indirect costs) while low and middle income countries pay the cost by day of life lost. (15)

Furthermore, the cost of physical inactivity is likely to grow since low and middle countries develop. (15)

In the private sector, costs are even more of interest and managers not always understand the actual burden of physical inactivity.To prevent negative effect of inactivity, middle to large sized companies try to gather HR data in order to find patterns of absenteeism/presenteeism.

Literature have been established the role of physical activity programs and their relation to healthcare costs. In a study, a sample of 517 employees were studied and healthcare costs were compared between exercisers and non-exercisers. Exercisers were part of a corporate health and fitness program. Exercise was associated with cost reduction due to decrease in illness whereas illness increased among non-exercisers. The total healthcare cost for exercisers was almost 50% lower compared with non-exercisers. (18)

Stress or burnout due to longer working time might lead to being less physically active since the time to exercise become shorter and because people that work longer hours tend to be more tired when they come home from work. In general, a wide spectrum of health risks can be associated to long working hours. (19)

Physical inactivity might also trigger presenteeism.

Presenteeism means having reduced productivity at work due to health issues that can vary from physical sickness to mental problem, for example due to stress or other physical conditions. (20) (21)

Finally, as showed, sedentary behavior generates chronic conditions, which affect not only employees but also their productivity.

Obese employees experience a 4,2% loss in productivity due to health issues, which is convertible in 506 dollars per obese employee. (22)

The same can be said for diabetic employees. In fact, diabetes has a strong predictive effect of absenteeism and action to reduce BMI and prevent diabetes should be included in health program in organizations. (23)

Overall, sedentary behavior affects negatively our society in two main ways. The first one is a direct negative effect on the health of citizens that, by being physically inactive, have higher chances to have chronic conditions and thus increasing probability to burden the healthcare system. The second negative outcome is because the very same employees who lack enough daily movement are less productive in their daily jobs.

1.5. THE BENEFIT OF PHYSICAL ACTIVITY

Being physically active means exercising e.g. practicing sports, but it also indicates the mere movement of the body and it is in opposition with a sedentary behavior mainly characterized by very limited amount of movement.

It has to be specified that “physical activity”, “exercise” and “physical fitness” are worlds that indicate different topics even though they are often used as synonyms.

Physical activity is defined as bodily movement created in our body by muscles and it has an energy expenditure which is measured in kilocalories. Examples of physical activities are sports, dynamic occupational activities or other activities. (24)

Exercise belongs to the physical activity family and it is a physical activity that is planned for a specific interval of time. Often, exercise repeats with a certain temporary pattern and it has an aesthetic goal or it is related to improving physical fitness. (24)

Finally, physical fitness is defined as set of parameters to describe health or skills. Tests are designed to quantify those parameters. (24)

Literature provides a vast amount of studies showing that physical activity has positive effect on health by being a contributor to prevention of many chronic diseases. (46) (47) (48)

In particular, observational studies provide evidence that being physically active and thus having good fitness level, is associated with reduce risk of dying prematurely for any causes and in particular for cardiovascular disease. (46)

An important feature of physical activity is the fact that apparently, there is a dose-response relation, which means that people who exercise the most, have the lowest risk of dying prematurely. (25)

Several analysis have highlighted a reduction of at least 50% in mortality among people with high level of fitness compared to people who have a low fitness level. (33) (40) (41)

To increase health is important to increase fitness level, and in order to do so, general population can engage in many different activities, both during leisure time and at work.

Despite the differences related to type of sport practiced, both resistance and aerobic exercises have been associated with decrease in risk of type 2 diabetes. (26) (27) (28) (29)

It also appears that physical activity, which is done as part of a job or during leisure time is, associated with reduction in incidence of certain types of cancers, in particular colon and breast cancer. (30) (31) (32)

1.6. SUMMARY

It appears evident that increasing physical activity is an effective way for increasing health levels, reduce costs to the healthcare system and increase productivity level of employees.

Taken in account that adults in industrialized countries spend at least 1/3 of their time at work, interventions aimed at increasing physical activity at the workplace appear critical.

This is especially true for office workers since they spend most of their time working in front of a computer (42), and in seated position (43).

Furthermore, during office time, computer workers are more sedentary with less walking/standing time during working days than during leisure days. (44)

The main aim of JITAI Walk is to increase physical activity among office workers by routinely trigger interventions that prompt employees to walk a certain number of steps.

CHAPTER 2. SITTING, A TYPE OF SEDENTARY BEHAVIOR

As previously discussed, sedentary behavior is the absence of movement with a consequent metabolic requirement which is close to baseline. In Denmark, physical inactivity accounts for 7-8% of deaths, which amount to 50,000 yers of life lost every year and a reduction of life expectancy of the population of 9-10 months. (7)

One of the most common sedentary behaviors is sitting for extended periods. (21)

Sitting for long bouts of time has been suggested being associated with higher mortality risk due to cardiovascular disease. (1)

Observations from the middle of 20th century have shown that men with occupations that required sitting for long time had twice the risk of cardiovascular disease compared with men whose jobs were physically active. (4) These results still hold true now. (2)

For example, higher rates of cardiovascular events were noted for sedentary bus drivers and mail sorters in contrast to more active bus drivers and postmen. (5)

Similar conclusions were reported for sedentary and physically active workers working in the railroad industry. (6)

Even among physically active individuals there was a strong association between sitting and increased mortality. (23)

Sitting time appears to be independent from mortality rate if taken in account only levels of physical activity per se; for this reason, long periods of sitting cannot be compensated with occasional physical activity during leisure time even if people are more active than advised by guidelines. (1)

2.1. WHY EXCESSIVE SITTING POSES A HEALTHRISK?

Many are the potential causes that lead to health risks in association with extended sitting.

From different studies has emerged that restriction of movement shows adverse events to the change of the cardiac stroke volume and its output (2) and it changes tolerance to glucose (3).

As previously mentioned, epidemiological evidence has shown that too much exposure to sitting can pose health risk even though recommendation for weekly/daily physical activity are met. (1)

Sitting is classified as health risk per se for mainly two reasons. (8)

The first reason is that sitting and physical activity are poorly correlated and just by increasing physical activity, the health risks of sitting are not solved. (23)

In fact, during sitting, muscles are passive and insulin resistance increases. (24)

Consequently, insulin resistance influences the transport and oxidation of fatty acids in the muscular tissue; this process cannot be restored by merely perform seldom intense exercise and it needs a more continuous schedule of physical activity. (8)

2.2. BENEFIT OF BREAKING THE SITTING

Given all the literature at hand, it can be seen that people need to leave chairs more often both during working and leisure time by engaging in physical activity.

Breaking up sitting after a meal using short bouts of activity is associated with how genes of skeletal muscles express in term of cellular development, growth, metabolism of lipids and carbohydrates. (9)

Activities made of 2 minutes of movement every 20 minutes of sitting may have beneficial implications due to changes in expression of these genes. (9)

According to literature, interruptions during sedentary time were associated with beneficial changes in metabolic risk variables such as adiposity measure, triglycerides and plasma glucose (2-h plasma glucose). (10)

Furthermore, this beneficial effect on metabolic markers may also be an indicator of increased energy expenditure since there are frequent physical movements to shift from sitting position to an active position. (11)

Even for activities like standing, instead of sitting, results have shown a substantial increase in total energy expenditure and greater resistance to fat gain. (12)

However, some other studies show that in order to lower considerably postprandial glucose levels, it might be required to engage in activities that are metabolically more intense than simple standing. (15)

In regard to the number of breaks from sitting, a research shows that regular breaks (around 2 minutes) from prolonged sitting (around 30 minutes), have the capacity of lowering postprandial glucose and concentration of insulin in healthy adults with normal BMI. (13)

In addition to a positive effect on metabolic markers, switching position from seated to standing every 30 minutes during the workday, may lead to a significant reduction in level of fatigue and discomfort at the lower back in office workers. (14)

Interestingly, it has been shown that interrupting sitting with breaks does not influence appetite or the volume of consumed food even though the metabolic requirements increase due to the increased physical activity. (16)

Finally, it looks like all the different positive components of interrupting sitting such as type of activity, intensity and frequency, affect people differently according to their personal characteristics, nevertheless, interrupting sitting and change it with physical activity appears beneficial for anyone. (17) (18)

2.3. HOW MUCH PHYSICAL ACTIVITY?

Guidelines have been designed to help people to get sufficient amount of physical activity.

According to WHO (World Health Organization), children and adolescent aged 5 to 17 should perform a minimum of 60 minutes of moderate to vigorously intense physical activity every day. Among these activities there should be at least 3 sessions per week that aim to strengthen muscles and bones.

If the limit is exceeded, there will be additional health benefits. (19)

For the adult population, aged from 18 to 65, requirements are expressed in terms of 150 minutes of intense physical activity during the whole week or a mix of moderate and intense physical activity. (19)

For added benefits, increasing moderate physical activity to 300 minutes per week.

Activities that aim at strengthening muscles should be performed involving the major muscles groups for 2 or more days every week.

In adults aged 65 years or more the requirements are 150 minutes of moderate intensity physical activity during the week or, as a minimum, 75 minutes of vigorous physical activity per week. (19)

For added benefits, it is possible to increase moderate physical activity up to 300 minutes per week.

As practical example, a person can meet the aforementioned recommendations by walking briskly for 30 minutes 2 times during a week and then adding 20 min of jogging on two other days. Equivalently, the walks can be divided into more bouts of 10 minutes to reach 30 minutes of activity.

In addition to these aerobic activities it is important to perform activities that aim at increasing strength such lifting weight, body weight/calisthenics movements or other similar resistance exercises. (20)

CHAPTER 3. CAUSES AND INTERVENTIONS TO REDUCE SEDENTARY BEHAVIOR

This chapter addresses not only the interventions possible to reduce sedentary behavior but also the causes of low level of physical inactivity from a physical and psychological perspective. It is very important not only to act on symptoms but tackle the reason that starts it.

Physical inactivity has not to be address solely with technologies or with campaigns; it has to take into account the behavior of the individual on a given moment in time.

Awareness is an important variable that in physical activity could play a key role (8).

The beginning of the chapter offers an understanding of the awareness that people have of their own and someone's else physical activity level.

Subsequently, an analysis aims to show how wrong levels of awareness affect physical activity (and health).

As a conclusion, the chapter exposes the status of both technological and non/technological health interventions to increase awareness and thus, physical activity during daily life, including at the workplace.

3.1. AWARENESS OF SEDENTARY BEHAVIOR AND RELATED CONSEQUENCES

Although it looks easy to avoid sedentary behavior by introducing a weekly routine of physical exercise, it seems that people have difficulties in defining what a sedentary behavior is.

Studies show how people are not able to accurately define sedentary behavior and therefore they cannot foresee any relationship between sedentary behavior and negative health outcomes. (8) (59) (60)

When the question is turned upside down, people tend to be aware of how physical activity affects positively health and the tendency is to be generally interested in being more physically active. (1)

In studies conducted on children in Dutch schools have revealed that around 64% of the study population is not aware of the activity level, children who were aware, were more physically active. (2)

This tells that physical activity might help increasing sense of self. In fact, Ronda et al (2001) have pointed out that individuals that are less aware of their physical activity levels are also less inclined to start increasing their daily activity. (6)(61)

Furthermore, an accurate perception to health behavior has been linked to increased intention to change health risks behavior. (2)

It is therefore important to address primarily awareness of physical activity level since it has not been done extensively and classical programs have failed expectations. (3)

From data gathered from UK, mothers are not aware of the physical activity guidelines set by government. Since they do not know how much their children should be active, it is highly unlikely that guidelines alone are successful in changing behavior. (4)

Generally, in the adult world, despite all the effort and resources invested in promotional activities to increase physical activity, only a third of adults can accurately identify the guideline and therefore being aware of the required amount of physical activity. (5)

This is particularly true among unemployed and less educated people; and due to lack of knowledge, it has been estimated that only 36% of participants were found to meet recommendations. (5)

Some people have a general sense of awareness in their level of physical activity, but these feelings are often wrong, and people tend to either overestimate or underestimate. (53)

Overall, among 57% of inactive adults, 50% overestimated their physical activity levels and thought that they were following recommendations. (6)

A relation between physical activity awareness and BMI was found. People who overestimate their physical activity have been found having a lower BMI and they were engaged in more physical activity, but activity level was not enough to be classified as active. (8)

As opposite, people who underestimated their physical activity level had higher BMI and were less active. (8) This might suggest that over estimators have greater indicators of health compared to the under-estimator counterpart. (7) (9) (10)

This effect could be explained given a positive bias that over estimators might have in relation to health whereas under-estimators have a negative bias that prevent them from increase their activity levels. (63)

3.2. THE ACTIVE COUCH POTATO

Guidelines are important and programs that enforce behavior towards those required amount of physical activity help creating awareness. More has to be done to reach desired outcome for these kind of programs since, has seen before, self-awareness does not normally reflect real behavior.

A recent classification of people in the physical activity realm is the “active couch potato”.

An active couch potato is a person that manages to reach physical activity guidelines but spend the majority of time in sedentary behavior. As seen in the previous chapter, to meet WHO physical activity guidelines at work it is not a guarantee of vibrant health and, on the contrary, it can worsen health (62).

Active couch potatoes manage to do 30 minutes of moderately intense physical activity but spend around 70% of awaken time in sedentary behavior thus it appears therefore to be possible to be physically active and yet lead a sedentary life. (11)

3.3. INTERVENTIONS TO INCREASE PHYSICAL ACTIVITY

Given the possible causes of physical inactivity, some interventions have been designed in order to prevent behavior from resulting in health complications. Such strategies tackle the problem of physical inactivity from a technological and not technological standpoint.

3.3.1. COGNITIVE AND BEHAVIOR INTERVENTIONS

Cognitive and behavioral interventions both aim at resolving medical conditions by leveraging psychological strategies.

Cognitive interventions normally aim at increasing knowledge about a certain topic (i.e. physical activity and its effect on health) while behavioral interventions analyze behavior of a person (or group of people) in regard to given guidelines or programs. (54)

Behavioral strategies used in chronically ill adults show that they are superior to cognitive strategies therefore they are suitable to be used in other types of chronic behaviors (22).

Behavioral interventions include goal setting, monitor progresses, giving feedbacks, monitor consequences and monitor prescriptions. (12)

In regard to physical activity it has been found that education on the topic doesn’t increase the size of the desired effect since the population is generally already aware of the benefits of physical activity on health and therefore, designing effective practical plans and follow up on them has been found to be most effective. (12)

Concerning the modality of delivery, face to face behavioral interventions have been shown to be received better and the content was retained more compared to other modality such as mass media campaigns, emails although there is a lot of unexpressed potential in the computerized way to deliver interventions. (13)

3.3.2. STRUCTURED AND LIFESTYLE INTERVENTIONS

Structured interventions are made by planning training sessions on certain times of the week while lifestyle interventions address small lifestyle changes.

Structured interventions bring greater differences in the lifestyle of an individual who can encounter difficulties and consequently build resistance against the approach. Resistance leads soon to generate barriers such as lack of time, bad weather or lack of facilities. (15)

Therefore, analyze and understand what the root causes of unhealthy behaviors are, is a crucial point for an intervention. (14)

To help overcome barriers, lifestyle interventions aim at reaching physical activity targets by increasing behavioral skills of an individual. These behavioral skills are associated with accepting, adopting and sustainably maintaining activity that increase health.

Lifestyle interventions have been used as alternative to classical fitness-based activities with success. (16)

After all, structured interventions are effective, in fact, both lifestyle and structured interventions produced significant and comparable beneficial changes in physical activity such as increased overall cardiovascular fitness, regulating blood pressure and reducing percentage of body fat in 24 months. (16) Since the lifestyle intervention is easier to follow, it’s good news that it produces such a positive result. (16)

The benefits given by lifestyle intervention build a solid, cost-effective base for healthcare providers to help citizens to make significant improvements in physical activity levels, overall fitness and cardiovascular risk factors without the use of external structures such gyms and without attending high intensity fitness workouts. (55)

3.3.3. MASS CAMPAIGNS

Mass campaigns are a form of advertisement that can be used to spread medical guidelines or tips for creating a healthy behavior.

For example, the VERB campaign is a campaign used to promote physical activity in schools with kids between 9 and 13 years old by using paid advertisement with an ad-hoc commercial designed for the target group.

In just 1 year, the VERB campaign reached high levels of awareness with corresponding levels of physical activity. (17)

In Denmark, during the month of May, the Danish cyclist association (Cyklist Forbundet) holds a national campaign called “We cycle to work” (vi cycler til arbejde). Aim of the campaign is to increase physical activity across adult workers by generating a light competition both between and within organizations. In 2018, 58.437 employees joined the campaign. (63)

We cycle to work is a great example of how a mass campaign can increase physical activity on large scale.

3.3.4. INTERNET DELIVERED INTERVENTIONS

Since 2000 there has been an increase in internet usage of more than 300% that counts around 1.5 billion users worldwide which is around 23% of the world’s population. (18)

This growth resulted in both positive and negative effects on health since computer usage has also been linked with increased sedentary behavior. (64)

Especially true is that an increasing amount of people use internet to access health related information, this gives a very interesting opportunity to design and deliver interventions that aim to change behavior in regard to physical activity. (19) (20) (21)

Findings have shown that interventions delivered over the internet are effective for producing small although significant positive changes in physical activity. (21)

It has to be considered that, even if the beneficial effects are small, there is an amplification effect given the broad range of receivers among the growing internet population. For this reason, internet delivered interventions might have powerful implications for solving problems rooted to lack of physical activity. (22)

3.3.5. STANDING DESKS

A type of intervention typically found in the workplace is the use of standing desks.

Standing desks are type of working desks which height can be adjusted in order to work sitting or standing.

There is strong evidence that standing desks have the capacity of reducing sitting time and thus reducing sedentary behavior. (45)

Workplace regulations are country specific. In Denmark, if an employee’s job requires more than 2h of sitting or standing, the law impose to equip the employee with a standing desk.

Standing desks might not only be an effective tool for reducing sedentary behavior but also to promote health thanks to increased knowledge, self-efficacy and healthy eating. (46) (47)

Other types of desks are the walking desks, their aim is to actively increase physical activity. Walking desks are made of two main parts, the desk and the treadmill. The desk is a classical desk, which is fixed on top of a frame. At the bottom, a treadmill is connected with the lower part of the frame and allow employees to walk while working.

Both standing desks and walking desks have shown to have an ability for improving health outcomes when used consistently. (57) (58)

Treadmill desks have been shown to be superior in improving biomarkers (lower BMI, lower waist circumference, lower 2-h plasma glucose, lower triglycerides and higher HDL-cholesterol) in comparison with standing desks. These improvements might be linked to the greater effort required to use a treadmill desk. (48)

Both types of desks increase energy expenditure compared to sitting and this suggest that they can be helpful in maintaining energy balance. (49)

A study even indicated that, for obese employees, if sitting computer time was replaced by walking computer time by using a walking desk, the energy expenditure would increase by 100 kcal/h. In real life, if obese employees were to exchange sitting computer time with walking computer time with 2-3 hours per day, by eating the same number of calories, they could potentially lose 20-30 Kg per year, reducing cardiometabolic risk factors. (50)

Furthermore, standing allowed performance to be steady with no evident decrease in work performance over time. Although some training is needed to adapt to the new working style, treadmill desks have also shown to keep productivity at normal levels. (52) (53)

Changing posture was useful in reducing perceived workload. (51)

Task length does especially affect the benefit of standing desks. Substitution of prolonged sitting with prolonged standing might results in feeling of discomfort in legs, back or shoulders. (51)

3.3.6. ACTIVITY TRACKERS

Technology is evolving quickly, and it aims to provide support in our daily lives. It is especially true for the world of activity trackers which nowadays have taken the form of evolved watches, capable of quantifying daily activities and give an overview of someone’s physical activity, heart rate, calories introduced, calories burned and sleep analysis, just to name the most common features now available on the market.

Activity trackers register activities using sensors and advanced signal processing techniques. Data is normally stored locally on the device or sent to a server and a dashboard of the daily activities is shown to the user in order to get an instant feedback and to generate a sense of progress/regress.(23)

One of the main aims of activity trackers is to enhance physical awareness. Among the physical activity guidelines, the “10.000 steps rule” is a very popular type of physical activity parameter. (31)

However, as discussed in previous sections, the majority of people is not aware of their compliance with recommendation. Under estimations or over estimations of actual walked steps is often present. Activity trackers help tackle this issue.

Visualizing data helps understand quickly and enhances awareness by looking at plots; users quickly grasp if their behavior reflects plans or some corrections have to be made. (24)

Furthermore, thanks to the world of social media, sharing results and other kind of data allows individuals to support each other and this may increase the possibilities of being consistent. (26)

Researchers have named the phenomenon of tracking activities “Lifelogging” (27), “Quantified Self” (28) or “Personal Informatics” (29).

Activity trackers offer the unique advantage to transform biomedical signal in data collected by motion sensors such as accelerometers that can be stored and analyzed. Data warehousing technique allow for both long plan and immediate interventions in order to correct unhealthy behaviors on a large scale. (56)

Similarly, mobile phone applications found their way into people lives and often (if not always) activity trackers have their own mobile application that helps showing data and support the user on different media. Mobile phone applications have been shown to be a source of motivation for increasing physical activity. (32) (33)

A mobile application requires more than developers to make people change their behavior.

In fact, changing behaviors by mixing activity trackers and related mobile applications has proven effective only when a behavioral changing technique was well developed within the mobile application. (35)

Examples of popular activity tracker devices on the market are Fitbit, Jawbone Up and Withings pulse plus and other smartwatches from brands such as Apple, Samsung and Garmin. (34)

3.3.7. SMARTPHONES

In the iTunes and Google Play stores are stored around 23.490 and 17.756 health and fitness apps respectively. Apps can be customized to user needs, they can provide feedbacks and the population reach is high. (36)

Since people carry smartphones everywhere and anytime, apps that aim at changing behavior and increase physical activity can use tailored feedbacks to be triggered at the right time or in the right place.

For this reason, mobile applications offer the opportunity to deliver real time, customized interventions that include behavior changing techniques.

Mobile health solutions are persistent, interactive, personalized and engaging and these characteristics give to mobile health the potential to become much more accessible, scalable and cost efficient. (44)

In the future, a collaboration between mobile application developers and behavior change experts could increase the use of behavior change techniques in smartphone applications and this might revolutionize the way we now promote health. (37)

Although applications turn out to be a paradigm shifter in relation to the delivery of health changing behavior, not all the apps contain the right content in terms of behavioral changing techniques. (42) (43)

3.4. SUMMARY

Interventions to increase physical activity should aim at increasing awareness among individuals that has been found to be perceived often incorrectly.

Among the types of different kind of interventions, the ones that can reach a broader audience are the ones delivered by internet or mobile applications since users are in growing number.

Furthermore, mobile application interventions leverage the fact that users carry their mobile phones almost anywhere and therefore ad hoc interventions are triggered when some specific conditions are met.

Together with signal processing techniques, mobile applications need to integrate solid behavioral changing techniques in order to facilitate the changing process.

CHAPTER 4. JUST IN TIME ADAPTIVE INTERVENTIONS. JITAI WALK

4.1. FEEDBACK

Feedback is a needed step in a loop in many different theoretical subjects, from technology to physiology and it applies particularly well to behavioural changes.

We, as humans, grow up and learn using feedback, which can be coming from ourselves (e.g. sensing unstable ground) or from someone else in our social network.

The role of feedbacks is particularly important in delivering health interventions via mobile application as it boosts awareness of personal behaviour. Without feedback, we could not be sure on our behaviour since the intervention would rely solely on the person's perception and, as previously shown, it is not reliable (see Chapter 3).

A feedback, besides alerting a person on a specific behaviour, can be used as a teaching moment in order to explain how unhealthy behaviours can be easily changed.

In this thesis project, focus is on the basics of feedbacks, how to change unhealthy behaviour, one step at the time in office settings.

In this thesis project work, focus is on the use of computer feedback and, in particular, on feedback delivered by a mobile application, which can be delivered instantly and are virtually ubiquitous since can be triggered anywhere, as long as a measuring device is available.

Due to their quick computation capabilities, computers can be programmed to keep track of the user behaviour and analyse it on a prolonged period, thus delivering important information to deliver behaviour changing techniques.

4.2. JUST IN TIME ADAPTIVE INTERVENTIONS

Just in time adaptive interventions (JITAI) are interventions that aim to deliver a feedback to a user exactly when needed. JITAI can be used in many different topics such as smoke cessation, drug addiction or PA increase related interventions.

JITAI is mainly designed for mobile phone as they are increasingly present in everyday life. JITAI have an enormous potential for adapting the delivery of an intervention to the behaviour of a user in order to prevent negative health outcomes and actively promote adoption and maintenance of healthy behaviours (2).

One of the most important characteristics of a JITAI intervention is that it is designed to dynamically change according to the individual's needs, at a certain time and only at that time. (2)

This precision in the intervention is possible thanks to the increasing availability and precision of sensors in mobile phones. (1)

Sensors in mobile phone enable the monitoring of temporal signals and represent individual state in real time.

JITAI help overcome bureaucratic barriers such as obtaining and receiving treatment, including cost, availability of therapists, scheduling and traveling to appointments, stigma of disease, and lack of therapist training (3) (4) (5).

Concerning PA, JITAI are increasingly developed for supporting behaviour change (6) (7), eating disorders (8), alcohol use (9) (10), mental illness (11) (12), smoking cessation (13), obesity/weight management (14) and other chronic disorders (15) (16).

However, despite the rapid diffusion of this technology, JITAI is still an immature field that needs to be explored more in order to become scientifically valid in a scientific context (17) (18) (19).

In fact, as shown in previous sections, mobile applications for delivering health interventions are not mature and behavioural change has to be carefully embedded in these kinds of applications (see chapter 3).

Designing a JITAI usually requires a multidisciplinary effort which involves clinicians, developers, behavioural scientists and human-computer interface specialists. In this project, I boldly embraced the effort by relying solely on the knowledge provided by the available literature and other technical support found on internet. (20)

To clearly define the JTAI intervention carried out within JITAI Walk, the different components of the JITAI are now described.

4.3. WHY JITAI

The reason for designing a JITAI intervention comes from the unpredictability of the real-life environment, which, in opposition of a laboratory environment, cannot predict users' status and related behaviour.

In fact, employees might need to sit more than expected because a meeting just got longer or because they spend more time at the canteen chatting on a problem arisen during the workday. All these events make real life situation much less predictable than a laboratory setting in which researchers plan and define all the steps during an experiment. Lower predictability calls for greater elasticity in the design of the intervention since it has to be taken in account the entire possible case scenario that "can" happen but that might not define an employee's behaviour.

Theories focused on prevention of adverse health outcome such as stress theory (21), and relapse prevention theories (22), show that the emergence of a state in which a subject is vulnerable and susceptible to a negative health behaviour is a dynamic process and anything around the subject can play a role towards the resulting behaviour.

In fact, during the experiment, any reason might make employees more vulnerable to be less physically active.

In this context, JITAI Walk identifies the individual behaviour and deliver the intervention in order to prevent the adverse health outcome. (23) (24) (25)

When external factor lead employee to be less physically active, JITAI Walk will trigger notification to break the inactivity pattern.

JITAI allow to generate a sort of “step by step” motivation which allows individuals to adopt and maintain healthy behaviours by providing short term, achievable goals and reinforce good outcomes immediately (26) (27) (28)

In JITAI Walk, this step-by-step motivation is expressed in the individual threshold calculated when the application is started for the first time.

Calculating an individual threshold means that every user will have a step threshold, which is dependent to the average of steps, performed during the baseline week.

Using an individual threshold versus a static one has the main advantage of increased engagement for less active employees who would feel discouraged by having a too high threshold. (56)

For example, if less active employees habitually walk an average of 300 steps/hour, it would be unrealistic to think that they would suddenly walk an average of 1.000 steps/hour. Too high goals would feel unachievable and thus, employees would not even attempt to walk when advised.

Overall, JITAI is a type of intervention developed to prevent falling in negative health behaviours due to moments of vulnerability and promote healthy behaviours and help maintain them by providing support at the right time or place.

A notorious example of JITAI in the area of behaviour change is FOCUS (29).

FOCUS delivered behaviour intervention to people affected by schizophrenia.

FOCUS was designed to trigger notifications to participants three times a day for assessments of difficulties in five areas (medicine adherence, mood regulation, sleep, social functioning and coping with persistent auditory hallucinations).

When the applications assessed difficulties in patient’s behaviour, FOCUS recommended self-management strategies.

On the contrary, if FOCUS assessed no difficulties, it was triggering positive reinforcement notifications that helped patients continuing with the behaviour.

Other JITAI have been designed in other domains, BASICS addressed heavy drinking and smoking (30) (31), SITCOACH aimed at increasing physical activity among office workers by checking laptop activities (32) and TXT2STOP aimed at quit smoking by SMS delivery (33).

4.4. COMPONENTS OF JTAI

JITAIs are adaptive interventions (AI) specifically designed to deliver an intervention at a specific time.

AIs have four main components:

1. Decision point
2. Intervention options
3. Tailoring variables
4. Decision rules

A decision point is a point in time at which an assessment must be made.

Decision points in JITAIs may be dependent on the experiment designer(s) or it is initiated by the participant and they are flexible.

If the decision point in a JITAI is decided by the experimenter, it has to be decided what is the trigger of a specific decision. For example, a researcher could decide to monitor continuously the position of a subject and it can be detected if a recovery participant is close to a liquor store (34).

In this case, the location is the decision point and it is defined by the researcher.

Decision points can be temporal (days during the week) (35) or they might be given from individual self-reporting.

Decision point initiated by the participant are typically points in which the participants explicitly needs support(36) (11).

In JITAI Walk, the experimenter defines the decision point and it is defined as a point in time (every 30 minutes) during the workday (from 8 to 16.30 Monday to Friday).

4.5. INTERVENTION OPTIONS

Intervention options include the type of delivered support, for example emotional or technical) and the source of support (automated support, social support), and modes of delivery.

In JITAIs, intervention options can be delivered at any time a certain need arises (37) (38).

These modes of intervention option are known as “Ecological momentary intervention” (EMI) and these are often used to describe interventions that can be delivered any time during the day of an individual. (39) (40)

In other science fields such as organizational behaviour, these interventions are defined as “micro interventions” to underline the shortness of the delivery and the instantaneous activity (41).

In JITAI Walk, the intervention option has been defined as emotional and technical since the mobile applications delivers an emotional message to trigger an increase in PA and provides support in moving even without leaving the desk.

The interventions delivered by the app JITAI Walk are delivered at any time during the working day of the employees, when needed.

4.6. TAILORING VARIABLES

A tailoring variable is an information used for making a treatment decision. In JITAI tailoring variables are collected in a flexible manner. This flexibility is essential to deliver an intervention just in moment of need.

Tailoring variables can be collected in 3 different ways, active assessment, passive assessment or both (42).

Active assessments are done by the individual and require that the individual is engaged. These assessments can be initiated by an individual or automatically by a system that asks the value of a certain variable, for example, asking to a subject how much, from 0-10 is his/her smoking urge.

Passive assessments require minimal or no engagement of the individual. All the activities are monitored automatically by the applications.

Innovation and advances in mobile phones have provided hidden methods for collecting information about the individual and the environment around and how they relate to each other. For example, it is possible to detect passively if an individual is going to be stressed (43) (44) (45) and then prevent alcohol consumption (46) or smoking (47).

Passive data can also provide information on the engagement of an individual with the app used to deliver the intervention (17).

In JITAI Walk, the tailoring variable is the number of steps walked and it is gathered passively as the employees do not need to interact with the app. Step count is done on the background both to calculate the individual threshold and to calculate the number of steps walked in the previous 30 minutes.

The whole JITAI Walk design is based on passive assessments because it is important to minimize employees' interaction with the app that might result in reduce working productivity. Detection of physical inactivity is also performed passively, and it is performed by accessing the number of steps done by an employee the last 30 min and comparing the value against the threshold.

4.7. DECISION RULES

Decision rules in JITAI individualize the delivery of an intervention, they link the tailoring variable and the intervention options in a systematic way. It is defined a decision rule for each decision point.

For example, in JITAI Walk, the decision rule, at every decision point (30 minutes) is defined as follows:

```
If steps walked previous 30 minutes < steps threshold

        Then

                intervention option = [trigger notification to increase PA]

        Else

                intervention option = [trigger notification to reinforce good behavior]
```

.

4.8. JITAI FOR PHYSICAL ACTIVITY ON THE WORKPLACE

As shown before, JITAI are suitable for different kind of interventions such smoke cessation or addiction. In literature, it has been researched, although not extensively, the use of JTAI for increasing physical activity.

In fact, many of the different interventions employed have produce only modest evidence of reduced sedentary time (48) (49) (50).

Other interventions resulted in a greater reduction in sedentary behaviour, but they included external equipment, which can be expensive and suitable only for experimental settings (51).

Sitting at work is a habit and does occur many times per day, sometimes for long periods. Therefore, interventions aimed at reducing this type of behaviour should require minimal effort from employees (52).

Nowadays, the use of mobile phones is widespread. In Europe, the daily usage of smartphones has been estimated to be 223 minutes (53) and in Denmark, 75% of all citizens have access to a smartphone (55).

Full time employees in Novo Nordisk A/S are all equipped with iPhones (5s, 6 or 6s) and thus the choice of developing JITAI Walk using an app created solely for iOS.

Furthermore, as previously explained, iPhones carry embedded sensors that have the ability to provide information on daily lifestyle of employees. For example, embedded accelerometers and gyroscopes deliver information to the motion coprocessor, which combines it, order to precisely register steps performed throughout the day. Because of this versatility, iPhones are a well-suited tool to deliver JITAI Walk during working hour in order to increase PA (54).

4.9. SUMMARY

JITAI are designed to deliver support in a timely fashion in order to address vulnerability that could lead to unhealthy behaviour and to help individuals in need to progress towards the adoption and maintenance of healthy behaviours.

The individualization of a JITAI aims to address the specific dynamic need of an individual, by providing support needed, in the right amount and at the right time.

The delivery of an intervention occurs through a decision rule which is a specification of which intervention option should be delivered and when, based on the tailoring variable.

Mobile devices provide the needed flexibility required by a JITAI. (20)

CHAPTER 5. EXPERIMENT DESCRIPTION

5.1. INTRODUCTION

The experiment consisted of a real application of a JITAI in working environment among office workers. The aim of the experiment was to establish if a JITAI is suitable for increasing physical activity among office workers during office hours at Novo Nordisk A/S. The JITAI is designed for the experiment is called JITAI Walk and it has been carried out by creating a mobile application (also called JITAI Walk) which triggers a message that encourages employees to walk. Results of the experiment will be discussed in the next chapter.

5.2. EXPERIMENT BACKGROUND

As discussed in previous chapters, sedentary behaviour affects negatively health and increase costs both in public and private sector. (1)

The aim of the experiment was to test if a JITAI intervention on the workplace could successfully increase physical activity among office workers. Office workers were chosen since their job is characterized by high level of sedentary behaviour (2).

Generally, the beneficial effect of increased physical activity in office settings is widely understood and many employees would like to move more. Often, office workers tend to be extremely focused on their tasks and lose the ability of estimating their sedentary behaviour. Employees sometimes simply forget that they have been sitting for more than 1h and it is very important to break long bouts of sitting. This JITAI aims at increasing awareness of personal physical activity level by triggering a personal message that encourages employees to walk.

A minimum of 10.000 steps per day has been shown be well known daily threshold for ensuring enough physical activity but it cannot be sustainable for everybody (3). This threshold was not used in the experiment since people all have different activity levels and for some employees, setting a high threshold of steps would be an unreachable target. For this reason, an individual threshold was used instead. The app calculates how many steps were performed in the baseline week and a threshold was therefore defined by obtaining the numbers of steps every 30 minutes (See source code for complete calculation).

5.3. MATERIAL AND METHODS

Employees were enrolled by sending out a common email within the department. In order to participate. To participate, employees were required to be:

- Full time employed
- Working in the department
- Be at the office during the baseline week and during the intervention week.

Participants gave their informed consent by signing a document.

The baseline week was a week of 5 full working days, working hours were considered to be from 8:30 to 16:30 from Monday to Friday. In the experiment, the baseline week was week number 16- 2018.

The intervention week was exactly like the baseline week. For the experiment, intervention week was week number 18-2018.

On the Friday prior to the experiment, participants were provided with the app and a short user guide was sent via email. The experimenter was available for questions or technical support during the whole duration of the experiment.

During every day of the intervention week, a morning and an afternoon reminder were sent to participants to remember to start and stop the application. At randomized intervals, emails were sent to remind participants to bring the phone with them when moving away from the desk.

The morning email stated the following:

“Dear brave participant of my experiment,

Please, remember to START the app.

I wish you a great walking day.”

The afternoon reminder stated the following:

“Dear brave participant of my experiment,

Please, remember to STOP the app”

On the morning of the first intervention day, the experimenter made sure that everybody started the application.

5.4. MOBILE APPLICATION DESCRIPTION

The mobile application was designed using Swift 4.1 programming language using Xcode 9.3 as developing environment.

The app was designed specifically for iPhone 5s, 6 and 6s since they were the phones used by the Novo Nordisk A/S employees. iOS software version was 11.3 or greater.

The source code of the application can be found in the appendix section.

The app can be divided in the following sections:

1. Start up and gathering necessary approvals
2. Calculating dynamic threshold
3. Start
4. Run
5. Enter the background
6. Notify

7. Stop

In the next paragraphs, the different sections of the app are described. Every section of the app has a main duty.

1. **Start application**

In the start-up section, the app gathers the needed approvals from the user. In order to run the app, it is necessary that the user allows receiving notifications and sharing fitness information (number of steps). This is done in accordance with Apple regulations. Data was never used to control employees in any way. No data was directly transmitted from the iPhone to an external storage.

The start section is represented by the following source code:

```
    func initNotificationSetupCheck() {

        if #available(iOS 10.0, *) {


UNUserNotificationCenter.current().requestAuthorization(options:
[.alert])

            { (success, error) in

                if success {

                    print("Permission Granted")

                } else {

                    print("There was a problem with the notification
permission!")}}}
```

All steps were gathered by accessing steps recorded in the iPhone fitness tracker which stores data up to 1 week. Access to the data was done by instantiating an object "CMPedometer" from the package "CoreMotion" and by sending a query to the object with a specific date. Response from the object was the number of steps. All operations performed with the accelerometer were performed by following the official Apple™ documentation.

Since September 2013, with the release of the Motion Coprocessor M7, Apple™ has introduced motion coprocessors.

Although the algorithm used from Apple™ is proprietary and hidden, it is known that the iPhone embedded accelerometer senses the acceleration on 3 axes. The values of acceleration are sent to the motion coprocessor which, by applying signal analysis and pattern recognition algorithms, is able to identify steps. Furthermore, the motion coprocessor takes in account also gyroscope data which is combined with accelerometer data to increase accuracy.

When step data is computed by the motion coprocessor, it is sent to the pedometer app inside Health which stores it since the day the iPhone was activated.

When developing an iPhone app, it is possible to access step data in 3 different ways:

1. Access raw data from the accelerometer
2. Access data in the motion coprocessor
3. Access data in the Health app

Accessing raw data (also known as raw events) means to apply manually signal processing (filtering and signal manipulation) and use pattern recognition techniques to understand which kind of 3D acceleration is to be considered a step. Overall, accessing raw data allows to have more data control but at the same time slows done processing since all the calculations need to be computed in the main CPU.

JITAI Walk access data in the coprocessor. To do so, a Pedometer object is instantiated and queried. Signal processing is done by the coprocessor which combines raw data from the accelerometer and from the gyroscope. Accessing data in the motion coprocessor allow lower data control since the analysis is done automatically but it ensures higher processing speed since calculations are ran asynchronously from the main CPU.

Access data in the Health app requires access to the HealthKit, which is the main health database in the iPhone. Developing an app for HelthKit requires a slightly more difficult programming paradigm than accessing the motion coprocessor data.

Since there were no benefit of developing the app with access to HealthKit, and data control was not a requirement, it was preferred to access steps from the motion coprocessor.

Access to motion coprocessor data is shown in the following source code:

```
            if(CMPedometer.isStepCountingAvailable()){

                pedometer.queryPedometerData(from: TuesdayFrom!, to:
TuesdayTo! ) { (data : CMPedometerData!, error) -> Void in

                    print(TuesdayFrom,TuesdayTo)

                    print("Steps   in   test   direct   data   Tuesday:
",data.numberOfSteps)

                    self.stepsWeek[1]        =        Int(truncating:
data!.numberOfSteps)

                }

            }
```

2. Calculation of individual threshold

In the second section, the app calculates the threshold of steps. The calculation looks back at the baseline week and calculates the average number of steps done between 8:30 and 16:30, from Monday to Friday. To do so, 5 pedometers objects (one for each day) are instantiated and set to deliver data via query for the 5 working days at specified time (8:30 – 16:30). The numbers obtained by the query are corrected by adding 20% because the iPhone's accelerometer calculates around 20% less steps, during walk at low speed (4).

Individual threshold calculation is represented by the following source code:

```
for number in self.stepsWeek {

  self.stepsThreshold += number

                    self.thre=self.stepsThreshold/self.stepsWeek.count

self.theThreshold=((self.thre*20/100)+self.thre)/16
```

The individual threshold ensures that the threshold adapts to users' activity patterns. Employees that are normally more active will have a higher threshold while employees that are more sedentary will have a lower threshold. Dynamic threshold is only calculated the first time when the app is started, and it is kept constant for the whole experiment for each individual. In future applications, this feature could be develop aiming at ensuring a stable and ad equate level of PA.

3. Start

Once the participant presses on the "start" button, the app starts a timer that counts cycles of 30 minutes. The timer is set in seconds so in the code 1800 seconds express the 30 minutes interval.

The start action is represented by the following source code:

```
timer = Timer.scheduledTimer(timeInterval: 1800, target: self, selector: #selector(self.timerAction), userInfo: nil, repeats: true)
```

4. Run

In the running section, every 30 minutes, the app compares the number of steps done the previous 30 minutes against the threshold. If the employee has performed less steps than the threshold it means that he/she did not walk enough, and a notification is triggered. If the number of steps performed last 30 minutes is greater than the threshold then it means that the employee walked enough, and a positive notification is triggered and sent to the screen.

The run section is represented by the following source code:

```
IfInt(truncating:data.numberOfSteps)<Int(self.theThreshold)

case Notifications

else Positive Notification
```

5. Enter the background

After running the app, it enters the runtime enters in the background stage and the app execution is not affected by other concurrent apps running at the same time. Furthermore, even when the app is closed by pressing the “home” button, the process is still running in the background. The only way to stop the runtime is to press the “STOP” button or to remove the app from the iPhone’s background.

The background mode is shown by the following source code:

```
    func startBackgroundTask() {

        NotificationCenter.default.addObserver(self,selector: 
#selector(interuptedAudio),name: 
NSNotification.Name.AVAudioSessionInterruption,object: 
AVAudioSession.sharedInstance())

        self.playAudio()

    }
```

6. Notify

Notifications include 4 different couples of messages and videos. Messages are used to make the worker aware of how long they have been physical inactive. In case walking was not possible, short videos provided physical exercises to perform on the place. Messages changed depending of the inactivity time, a message was set for 30 min, 1h, 1,5h and 2h inactivity.

Notifications are represented by the following source code:

```
let notification = UNMutableNotificationContent()

                        notification.title = "ALARM!"
```

```
                        notification.subtitle = "2 h of inactivity!"

                        notification.body = "You are going to be
healthier than 1min ago if you go for a walk"

                        notification.attachments = [attachment]

                        let notificationTrigger =
UNTimeIntervalNotificationTrigger(timeInterval: 0.5, repeats: false)

                        let request =
UNNotificationRequest(identifier: "notification1", content:
notification, trigger: notificationTrigger)
```

Notification stated the following:

30 minutes of inactivity: “Time to move! Cannot walk? Do this instead””

1 hour of inactivity: *“Not much activity for 1h! Your health is important. Consider going for a short walk”*

1,5 hours of inactivity: *“Not much activity for 1,5h! Your health is important. Improve your heart health!”*

2 hours of inactivity: *“ALARM! 2 h of inactivity! You are going to be healthier than 1min ago if you go for a walk”*

Videos were randomly assigned to the messages. Physical exercises shown in the videos were the following:

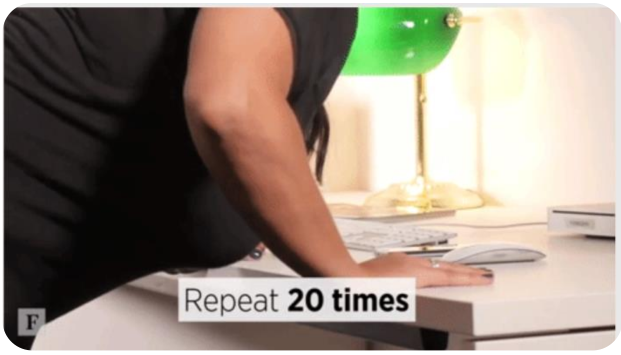
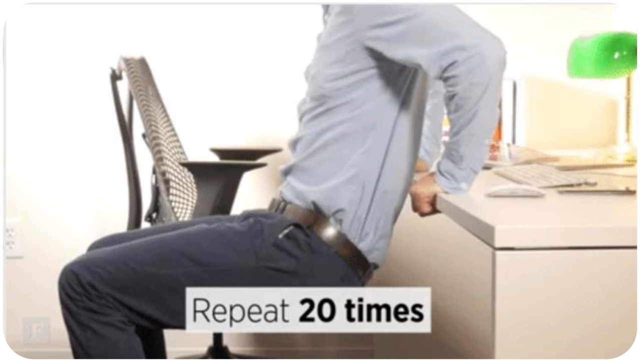
1 

Figure 1 - Notification video: “push-up”

2

Figure 2 - Notification video: "Wooden Leg"

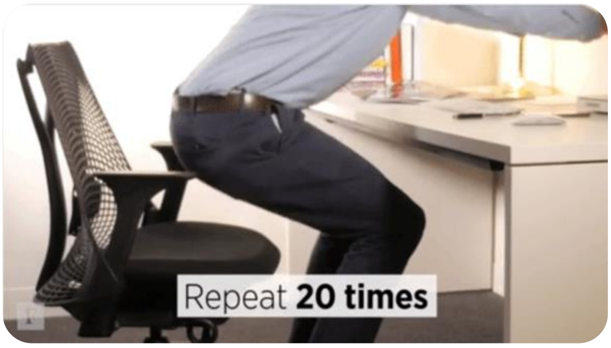


3

Figure 3 - Notification video: "Dips"

4

Figure 4 - Notification video : "Mermaid"



5

Figure 5 - Notification video : "Invisible Chair"

Notifications were displayed on the iPhone screen when the app was on foreground or in background:

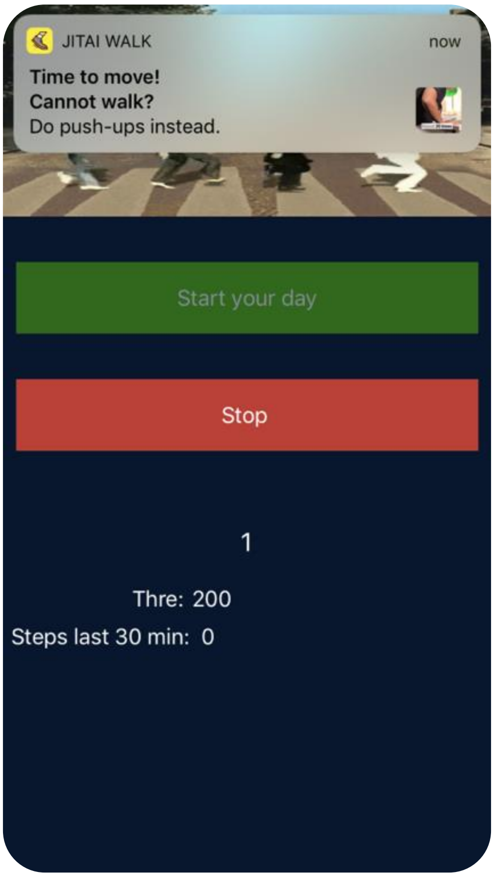


Figure 6 – Example of notifications shown in the top screen

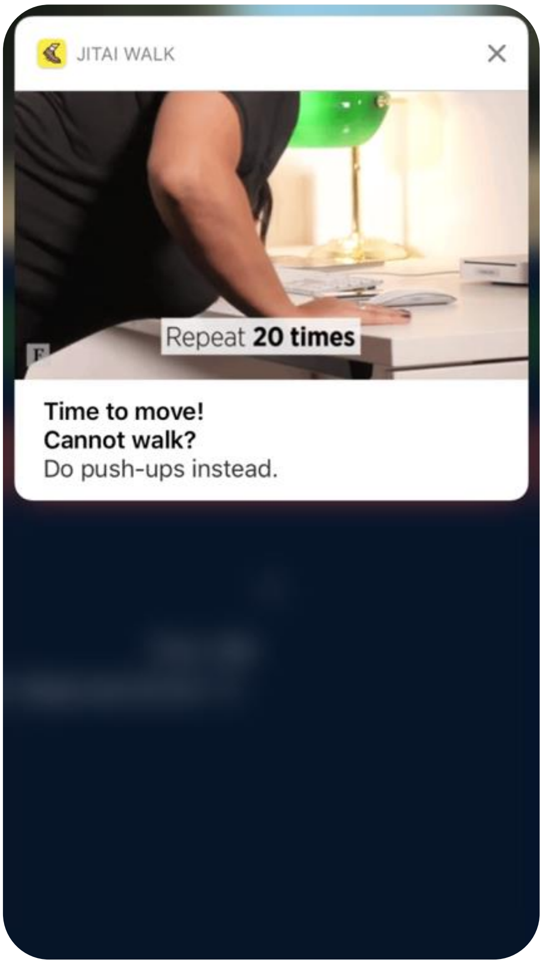


Figure 7 - If dragged down, notification would start the video exercise

If the employee was active enough the message would display a positive reinforcement such as (see picture after text):

"*CONGRATULATIONS! You have been active the last 30 min! Thanks for taking care of your life*"

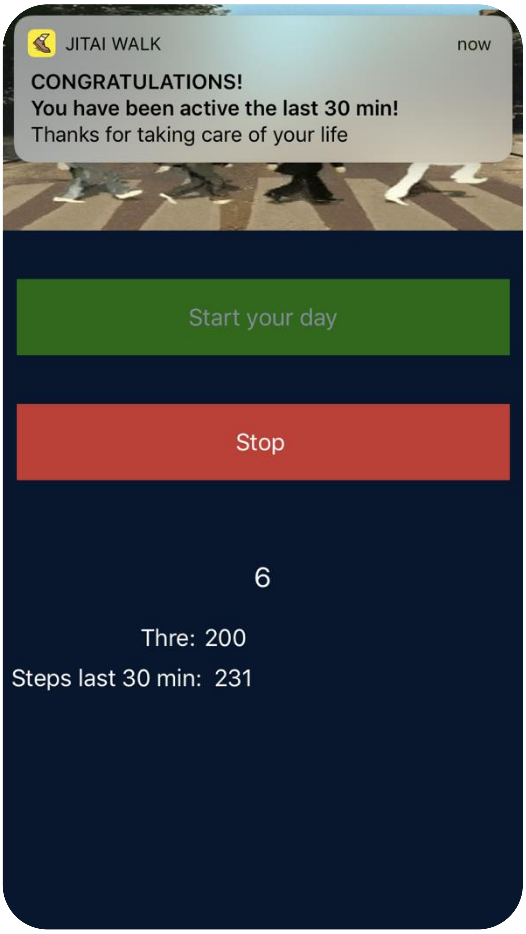


Figure 8 - Example of notification with positive reinforcement

7. Stop

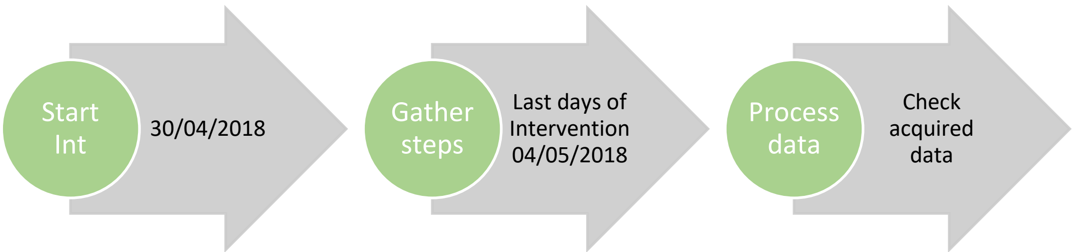
Once the “STOP” button is pressed, the timer and all the processes are stopped. To start again the app it is necessary to press on the “Start your day” button.

The Stop section is represented by the following source code:

```
@IBAction func stopBackgroundTask(_ sender: AnyObject) {

    starTaskButton.alpha = 1

    starTaskButton.isUserInteractionEnabled = true

    stopTaskButton.alpha = 0.5

    stopTaskButton.isUserInteractionEnabled = false

    timer.invalidate()

    backgroundTask.stopBackgroundTask()
```

5.5. REPRESENTATION OF THE PROCESS

Intervention Week



CHAPTER 6. DATA ANALYSIS

6.1. QUANTITATIVE DATA

Total number of steps performed for each day of both baseline week and intervention week were collected by using ad hoc apps that accessed the number of steps measured by the iPhone every day from 8:30 to 16:30 for each employee participating in the experiment. Source code is available in the appendix.

Data was analyzed by using SPSS statistic version 25.

The initial number of employees taking part in the experiment was 30. Unfortunately, 4 employees left for holidays on May 1st, 2 employees got sick, 1 employees forgot the phone at home during one day of the intervention week and 2 employees spontaneously said that they could not / would not use the app at day 1 and day 3 respectively. Finally, the intervention group was made by 21 employees, 9 males and12 females, mean age 36.8 years old, all participant had BMI < 25. All participants had the same time of job, they were all typical office workers with majority of time spent sitting.

Once data was gathered, the first step was to check normality. Shapiro-Wilk test was used to see if data followed a normal distribution.

Assessment of data normality is a prerequisite for many statistical tests because normal data is an underlying assumption in parametric testing. Normality can be assessed graphically and numerically.

Statistical tests have the advantage of making an objective judgement, but they have the disadvantage of not being sensitive enough when the sample is small.

Graphical tests allow good judgement to assess normality in situations when numerical tests might have too much or too little sensitivity, but graphical methods lack objectivity.

Normality was calculated both numerically and graphically by using SPSS and the results of descriptive statistics can be found in Figure 1 and Figure 2.

6.1.1. NUMERICAL ANALYSIS

The Shapiro-Wilk Test is found to be appropriate for sample sizes smaller than 50 elements, for this reason, the Shapiro-Wilk test was used as numerical means of assessing normality.

It can be seen from Figure 11 that for the two dependent variables (Steps_Baseline and Steps_Intervention) are not normally distributed as the Sig**.** value (p-value) of the Shapiro-Wilk Test is smaller than 0.05 for both. For this reason, the null hypothesis cannot be rejected, and data do significantly deviate from a normal distribution.

6.1.2. GRAPHICAL ANALYSIS

In order to determine normality graphically, the Q-Q plot was used. If the data are normally distributed, data points will be close to the diagonal line. If the data points are lay away from the line following a non-linear fashion, data are not normally distributed.

As can be seen in Figure 12 and Figure 13, the points in the normal Q-Q plots are not laying on the close to the diagonal and therefore the two variables are not normally distributed.

Finally, figures 14 and 15 show the histograms representing the two variables.

Descriptives

			Statistic	Std. Error
Steps_Baseline	Mean		12569.81	1235.350
	95% Confidence Interval for Mean	Lower Bound	9992.91	
		Upper Bound	15146.70	
	5% Trimmed Mean		12250.91	
	Median		12086.00	
	Variance		32047880.2	
	Std. Deviation		5661.085	
	Minimum		5255	
	Maximum		25689	
	Range		20434	
	Interquartile Range		6578	
	Skewness		.924	.501
	Kurtosis		.467	.972
Steps_Intervention	Mean		15516.43	1452.283
	95% Confidence Interval for Mean	Lower Bound	12487.02	
		Upper Bound	18545.84	
	5% Trimmed Mean		14750.41	
	Median		14160.00	
	Variance		44291649.8	
	Std. Deviation		6655.197	
	Minimum		7348	
	Maximum		38122	
	Range		30774	
	Interquartile Range		6245	
	Skewness		2.084	.501
	Kurtosis		6.090	.972

Figure 9 - Descriptive statistic to check data normality using SPSSS

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Steps_Baseline	.178	21	.080	.914	21	.066
Steps_Intervention	.217	21	.011	.814	21	.001

a. Lilliefors Significance Correction

Figure 10 - Summary of the 2 normality tests: Kolmogorov-Smirnov and Shapiro-Wilk tests

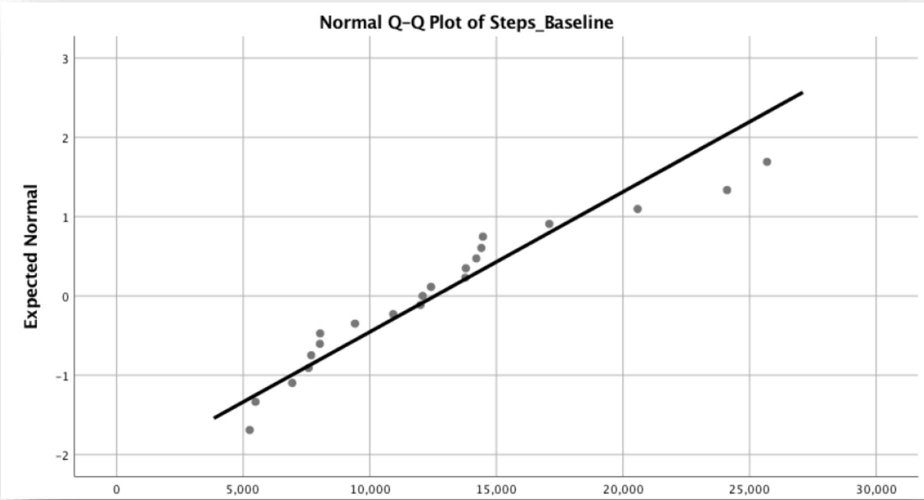


Figure 11 – Q-Q plot for the variable "Step_Baseline"

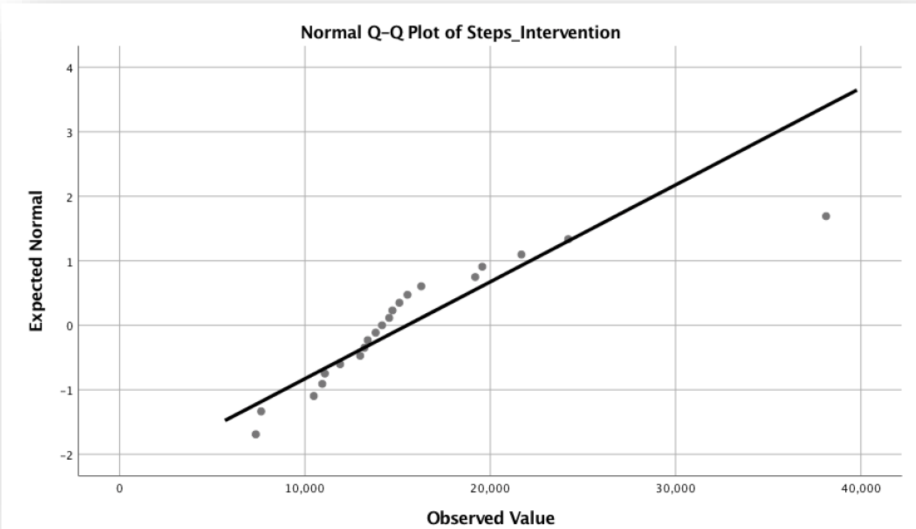


Figure 12 – Q-Q plot for the variable "Steps_Intervention"

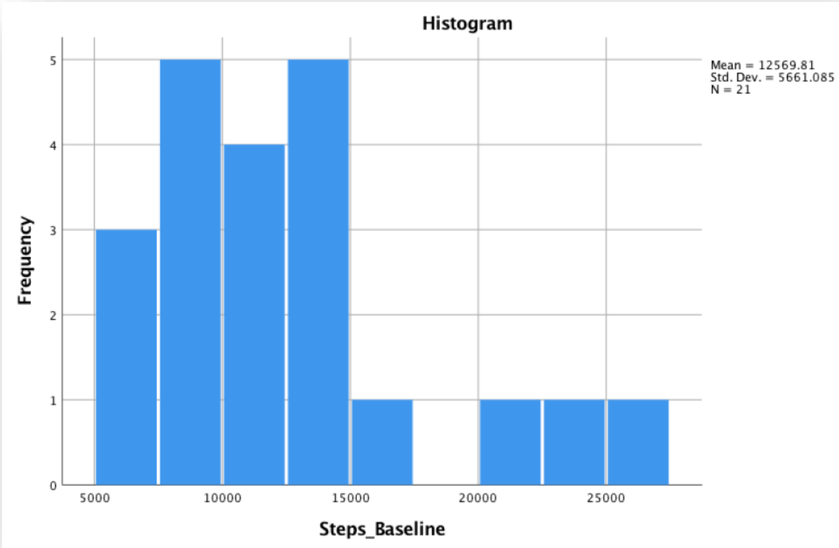


Figure 13 - Histogram of the variable "Steps_Baseline"

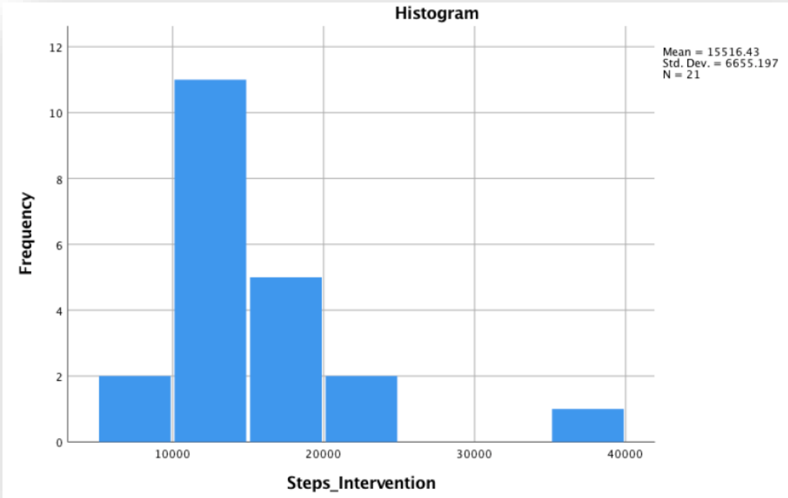


Figure 14 - Histogram of the variable "Steps_Intervention"

6.1.3. EFFECT OF THE INTERVENTION

To understand if the use of the app has had a statistically significant effect, the data from baseline and from intervention were compared by using Wilcoxon Rank test.

The Wilcoxon signed-rank test is used when there are two nominal variables and one measurement variable. One of the nominal variables has only two values, such as "before" and "after," and the other nominal variable often represents individuals. Wilcoxon signed rank test is the non-parametric equivalent to the paired t–test.

This statistical test has the following assumptions:

- Data comes from two dependent populations.
- The data is continuous.

Because it is a non-parametric test, it does not require that the dependent variables follow normal distribution.

Assumption 1 is respected since steps are recorded from the same group of people before and after intervention.

Steps are also continuous and, as seen before, they do not follow a normal distribution.

The null hypothesis is that the median difference between the observation at baseline and after intervention is zero.

The outcome of the Wilcoxon test gave a p-value < 0.001 (confidence interval .05) indicating that there was a statistically significant difference between the number of steps at baseline and after intervention. In fact, the weekly number of steps increased from 263.966 in the baseline week, to 325.845 during the intervention week. Figure 16 and Figure 17 show the output of the Wilcoxon test performed using SPSS.

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between Steps_Baseline and Steps_Intervention equals 0.	Related-Samples Wilcoxon Signed Rank Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Figure 15 - Output of Wilcoxon test resulted in p-value of 3E-4(in picture approximated by SPSS)

Test Statistics[a]

	Steps_Intervention – Steps_Baseline
Z	-3.597[b]
Asymp. Sig. (2-tailed)	.0003

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Figure 16 - p-value of the Wilcoxon test (3E-4)

In addition to the statistic shown until now, median, interquartile range and quartiles were also calculated since, as seen by the Shapiro-Wilk test, data is not normal.

The interquartile range is a measure used to quantify dispersion of data around the median. The interquartile range, in other words, provides an indication of the variability of the data around the median. A smaller interquartile range indicates that values are less dispersed around the median.

Half of all the values fall in the interquartile range which is the distance between first quartile (25th percentile) and the third quartile (75th percentile). If this number is large, there is a great difference between the 25th percentile value and the 75th percentile value.

For skewed (asymmetrical) data, the interquartile range is a better measure of the spread compared to the standard deviation since the interquartile range is not based on the assumption of symmetric distribution.

Median and inter quartile range have been calculated using SPSS statistic and are shown in Figure 18 and Figure 19:

Descriptives

			Statistic	Std. Error
Steps_Baseline	Mean		12569.81	1235.350
	95% Confidence Interval for Mean	Lower Bound	9992.91	
		Upper Bound	15146.70	
	5% Trimmed Mean		12250.91	
	Median		12086.00	
	Variance		32047880.2	
	Std. Deviation		5661.085	
	Minimum		5255	
	Maximum		25689	
	Range		20434	
	Interquartile Range		6578	
	Skewness		.924	.501
	Kurtosis		.467	.972

Percentiles

		Percentiles						
		5	10	25	50	75	90	95
Weighted Average (Definition 1)	Steps_Baseline	5278.10	5776.00	7858.00	12086.00	14435.50	23403.40	25531.10
Tukey's Hinges	Steps_Baseline			8029.00	12086.00	14404.00		

Figure 17 – Median, inter quantiles range and percentiles calculated with SPSS for the variable Steps_Baseline.

Descriptives

			Statistic	Std. Error
Steps_Intervention	Mean		15516.43	1452.283
	95% Confidence Interval for Mean	Lower Bound	12487.02	
		Upper Bound	18545.84	
	5% Trimmed Mean		14750.41	
	Median		14160.00	
	Variance		44291649.8	
	Std. Deviation		6655.197	
	Minimum		7348	
	Maximum		38122	
	Range		30774	
	Interquartile Range		6245	
	Skewness		2.084	.501
	Kurtosis		6.090	.972

Percentiles

		Percentiles						
		5	10	25	50	75	90	95
Weighted Average (Definition 1)	Steps_Intervention	7376.90	8204.80	11486.00	14160.00	17731.00	23701.60	36730.50
Tukey's Hinges	Steps_Intervention			11899.00	14160.00	16274.00		

Figure 18 - Median, inter quantiles range and percentiles calculated with SPSS for the variable Steps_Intervention.

6.2. QUALITATIVE DATA

Qualitative data was obtained from questionnaires sent to the employees 3 days after the experiment was conducted.

One of the questionnaires gathered information concerning app usability. The second questionnaire gathered information in regard to employees' productivity while using the app. Questionnaires were filled by every participant, a total of 21 questionnaires express the qualitative data.

Both questionnaires were designed with the Likert scale and the following answers were available:

1. Strongly agree
2. Agree
3. Indifferent
4. Disagree
5. Strongly disagree

Questionnaires can be found in the appendix.

6.2.1. APP USABILITY

Usability was assessed by the usability questionnaire, which was made by 7 statements:

1. The app was easy to use
2. It took a long time to understand how to use the app
3. The app didn't need much explanation to be used
4. It was easy to start / stop the app every day
5. I could use the app even after the experiment to remind myself to be more physically active
6. The app made me walk more
7. I am more aware of the fact that I need to be physically active during my time at work

Results are now discussed independently for each statement/answer.

Statement 1: The app was easy to use

61.9% replied “Strongly agree” while 38.1% replied “Agree” indicating that the app was easy to use.

This result is in line with the scope of the app when the graphic interface was design. Only two buttons were present on the main (and only) interface of the app thus keeping human errors at a minimum.

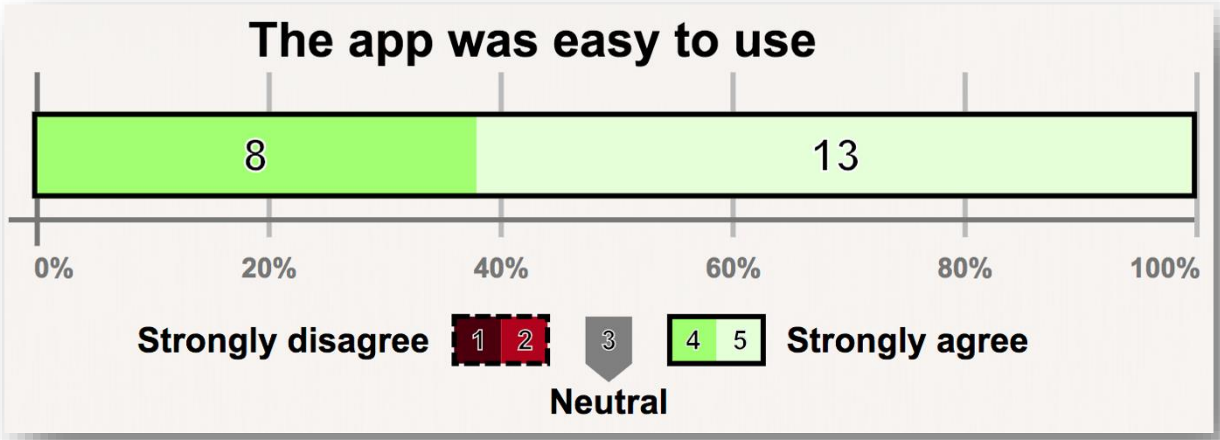


Figure 19 - Answers to the statement: "The app was easy to use".

Statement 2: It took a long time to understand how to use the app

66.7% of the participants replied "Strongly disagree", 23.8% "Disagree" and 9,5% were indifferent.

Again, results are aligned with the main idea during development. The app didn't need any interaction from the employees during its use. The only interactions needed were at the beginning and end of every working day during the intervention week.

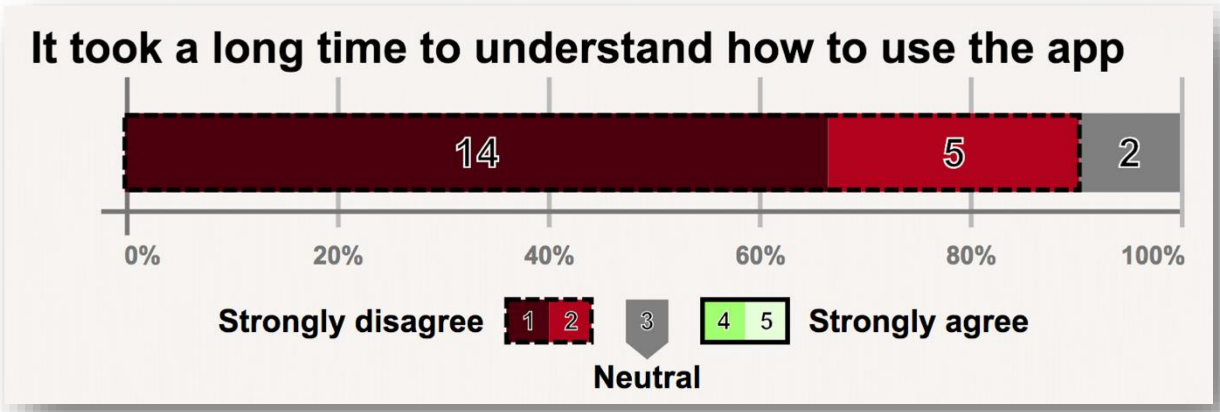


Figure 20 - Answers to the statement: "It took a long time to understand how to use the app".

Statement 3: The app did not need much explanation to be used

71.4% of the participants replied "Strongly agree", 19% "Agree", 4,8% "Indifferent" and 4,8% disagree. These results indicate that the majority of the people felt comfortable using the app without further explanation beside the ones initially provided. 1 person felt indifferent to the instructions and 1 person felt in need of more explanations.

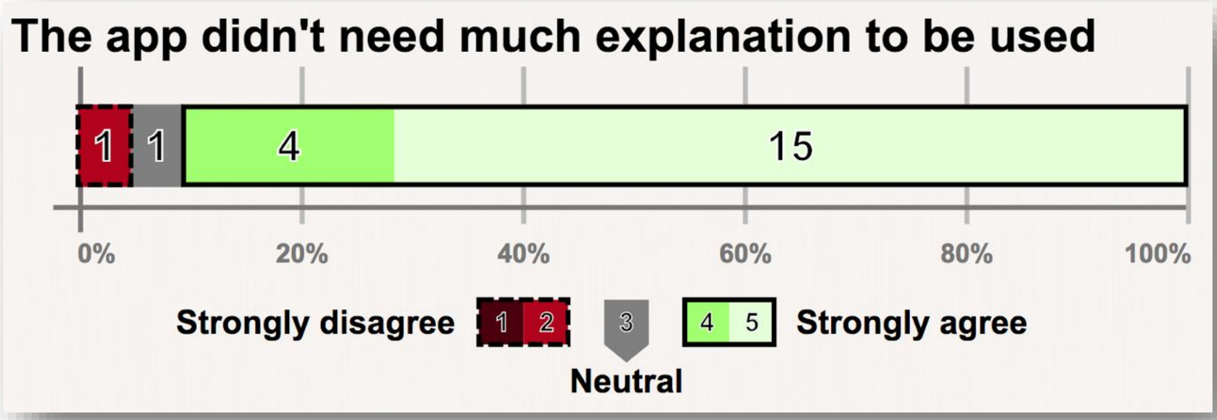


Figure 21 - Answers to the statement: "The app didn't need much explanation to be used".

Statement 4: It was easy to start/stop the app every day

57.1% of the participants replied “Strongly agree”, 33.3% replied “Agree”, 4,8% replied “Indifferent” and 4,8% replied “Disagree”.

This suggest that the majority was at ease when the app had to be started/stopped every day during the intervention week. 1 participant was indifferent, and 1 participant disagreed. Overall, results suggest that was fairly easy to remember to start and stop the app, also thanks to the reminders send via mail.

In a future version of the app, start/stop functionality could be done automatically, thus removing user interaction with the app. Removing interaction with the app might reduce the awareness effect of the intervention.

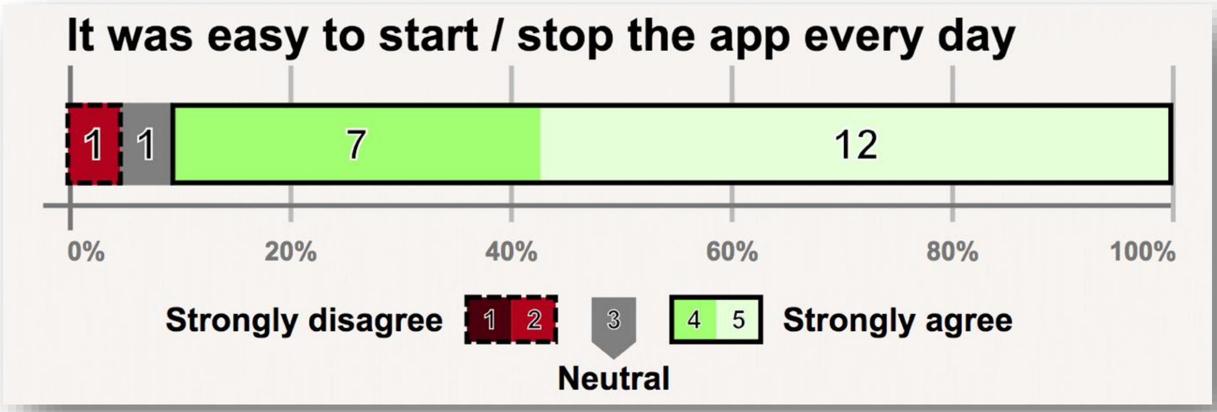


Figure 22 - Answer to the statement: "It was easy to start/stop the app every day".

Statement 5: I could use the app even after the experiment to remind myself to be more physically active

52.4% of the participants replied “Agree”, 33.3% replied “Indifferent”, 9.5% replied “Strongly agree” and 4.8% replied “Disagree”.

The majority of the participants stated that they would continue to use the app to be more physically active and this is a good result.

The indifference of seven participants might need to be studied further since it might come from the fact that the app was bothering them during the workday, for example during meetings or because they could be just reluctant to be more physically active during working time.

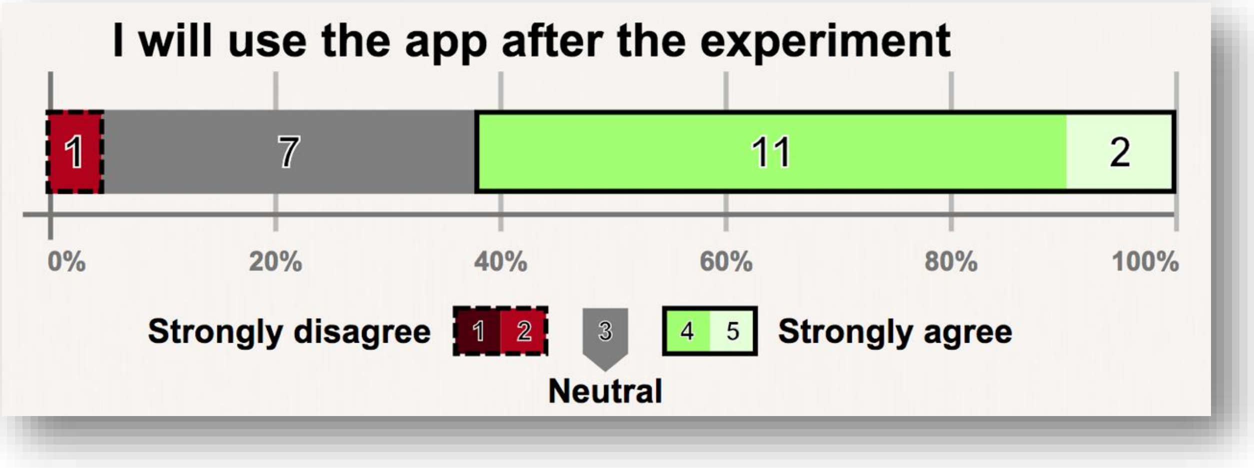


Figure 23 - Answers to the statement: “I could use the app even after the experiment to remind myself to be more physically active”.

Statement 6: The app made me walk more

47.6% of the participants replied “Agree”, 28.6% replied “Strongly agree”, 14.3% replied “Indifferent” and 9.5% replied “Disagree”.

Again, the majority of the participants followed the expected outcome of the intervention and felt to be more physically active. Compared against quantitative data, the feelings meet the numbers since almost every participant had an improvement in step count when compared with baseline.

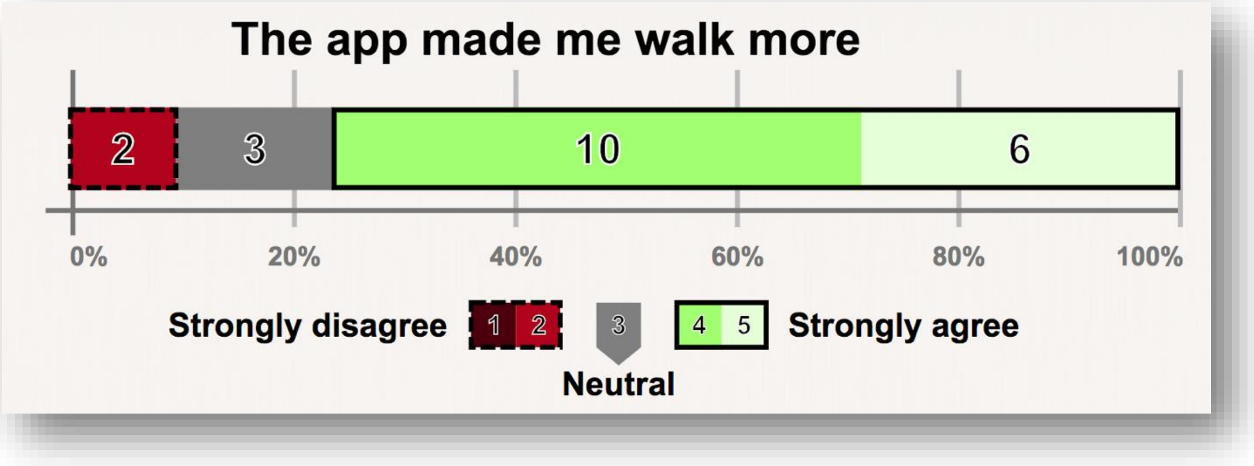


Figure 24 - Answers to the statement: "The app made me walk more".

Statement 7: I am more aware of the fact that I need to be physically active during my time at work

47.6% of the participants replied “Agree”, 33.3% replied “Strongly agree”, 14.3% replied “Indifferent” and 4.8% replied “Disagree”.

The majority of employees have shown to be aware of their lack of physical activity whereas some of them are indifferent and 1 employee disagrees perhaps because they are not aware of the benefits of being more physically active during work and in future versions of the app, this aspect could be included to further address the behavioral aspect of the intervention.

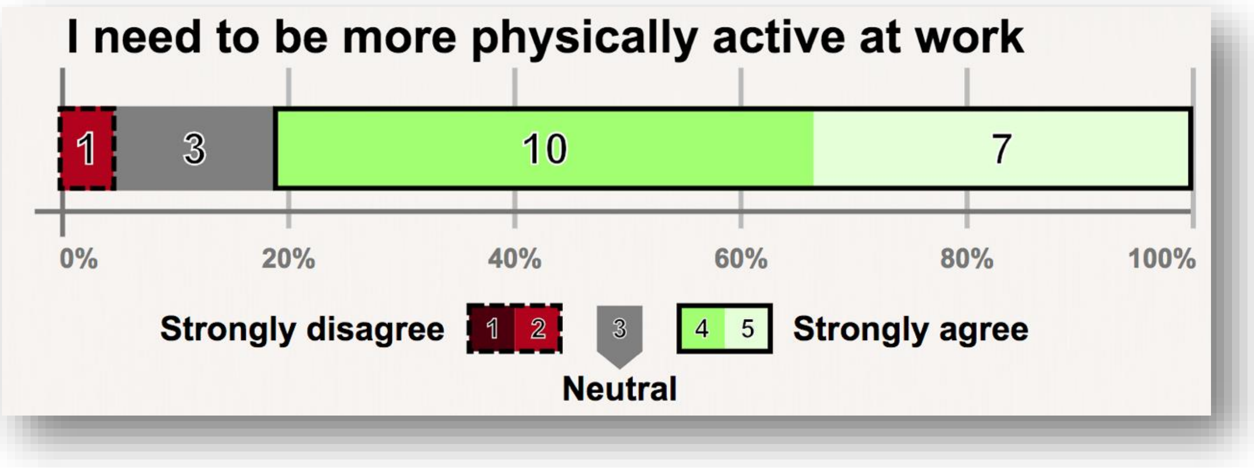


Figure 25 - Answer to the statement: "I am more aware of the fact that I need to be physically active during my time at work".

6.2.2. PRODUCTIVITY AT WORK WHILE USING THE APP

One of the point of strength of the experiment was the fact that it was carried out in a real office environment and not in the controlled settings of a laboratory.

For this reason, it was of interest to know how productivity was perceived by the employees participating the experiment. To measure perceived productivity, a questionnaire was provided 3 days after the experiment. Every participant filled the questionnaire (21 responses in total).

The productivity questionnaire was made by the 5 following statements based on the Likert scale:

1. Overall, the app didn't make me less productive
2. I could complete as many tasks as before using the app
3. I was as focused as much as before using the app
4. It was pleasant to take some time for myself when the app was beeping
5. When the app was beeping, my tendency was to follow the advice and go for a walk

Statements, replies and analysis are now shown.

Statement 1: Overall, the app did not make me less productive

52.4% of the participants replied “Agree”, 33.3% replied “Strongly agree”, 9.5% replied “Indifferent” and 4.8% replied “Disagree”. The majority of the participants felt that their productivity was not affected by the app.

This result was not expected since it was forecasted that, since the app was beeping every 30 min, employee would stop their tasks more often, thus feeling less productive.

An explanation for this could be that employees were managing their working time more effectively during the 30 min since they knew that after this time, they would have to take a break (1) (if they were not active enough).

It is overall a good result to know that perceived productivity was unaffected.

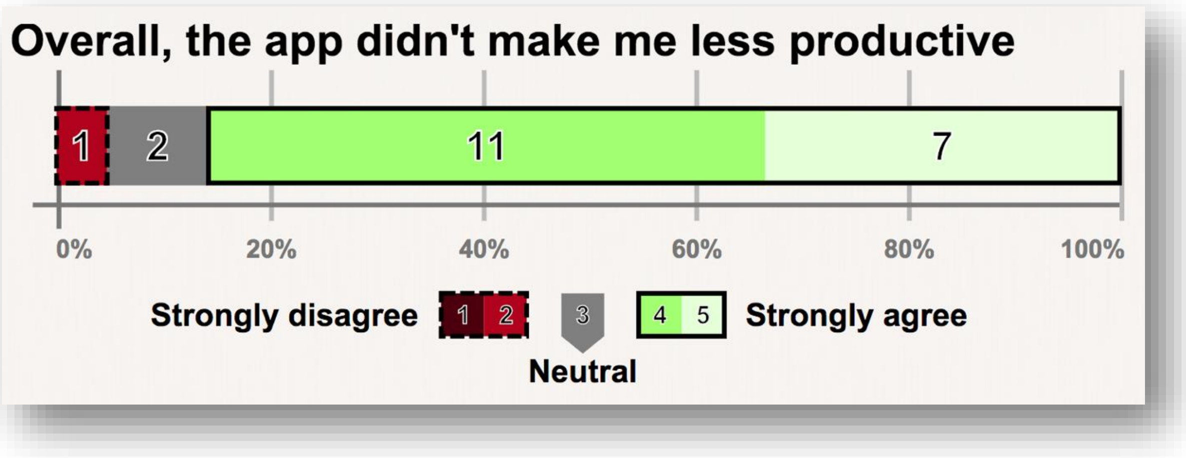


Figure 26 - Statement "Overall, the app didn't make me less productive".

Statement 2: I could complete as many tasks as before using the app

The majority of the participants agreed or strongly agreed that they could complete the same number of tasks while using the app. Two participants were indifferent to task productivity. Surprisingly, none of the participants disagreed, since in the previous question 1 participants disagreed to the statement.

This might indicate that employee might have different productivity index that do not rely on task accomplishment. Productivity measurement is actually a well-known problem in literature. (2)

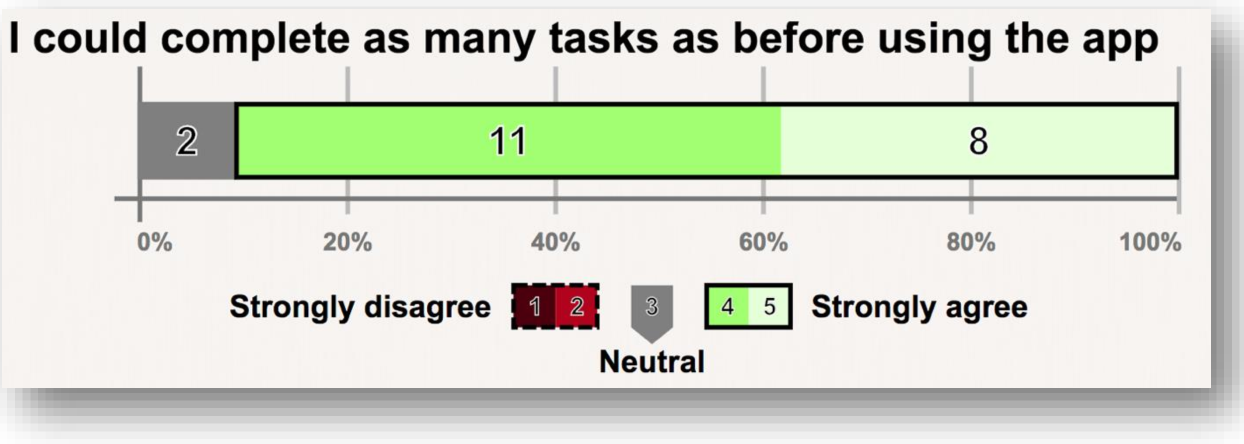


Figure 27 - Answers to the statement: "I could complete as many tasks as before using the app".

Statement 3: I was as focused as much as before using the app

The majority of the participants did not perceive to be less focused while using the app during the intervention week.

Three participants were indifferent, and two participants disagreed. The app was designed to require minimal intervention from the employees in order to minimize their distraction and these results show that the objective was accomplished.

For the two employees that felt less focused it might mean that their tasks require more than 30 min of focus and since they had to move away from the desk, they would be distracted, and this influenced negatively their focus and this behavior is aligned with literature. (3)

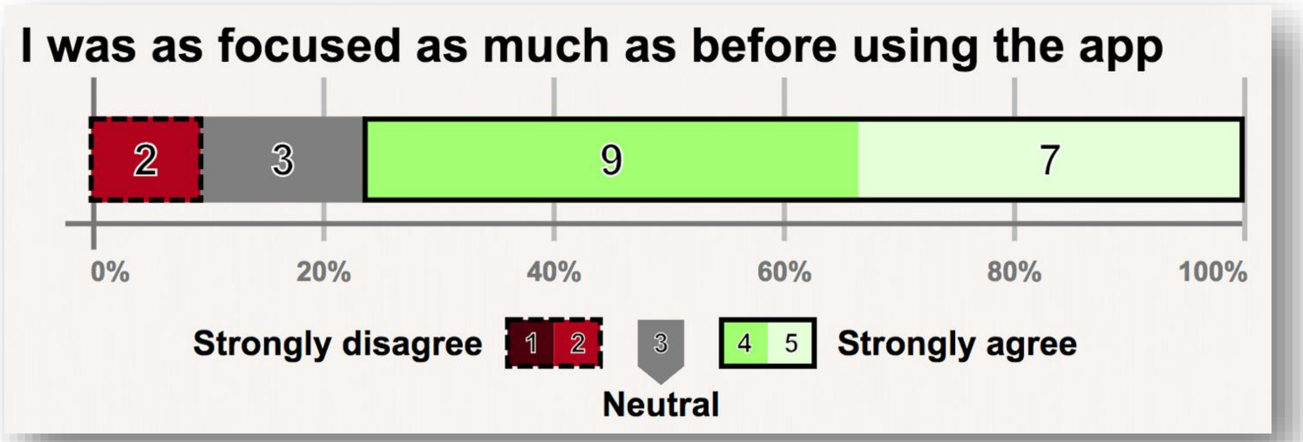


Figure 28 - Answers to statement: "I was focused as much as before using the app."

Statement 4: It was pleasant to take some time for myself when the app was beeping

With this statement, the experimenter aimed at understanding what was the overall feeling when participants were receiving a notification to go for a walk.

This statement (and the next one) are the ones that fragmented more participants. The majority agreed (38.1%+9.5%) with the statement while 33.3% of the participants disagreed (23.8%+9.5%). Finally19% of the replies showed indifference to the positive feelings of taking some private time.

These results might indicate that a forced break is less pleasant than a voluntary one, the idea to stop a task after 30 minutes of inactivity might have been perceived as difficult to do, and this is shown in literature. (4)

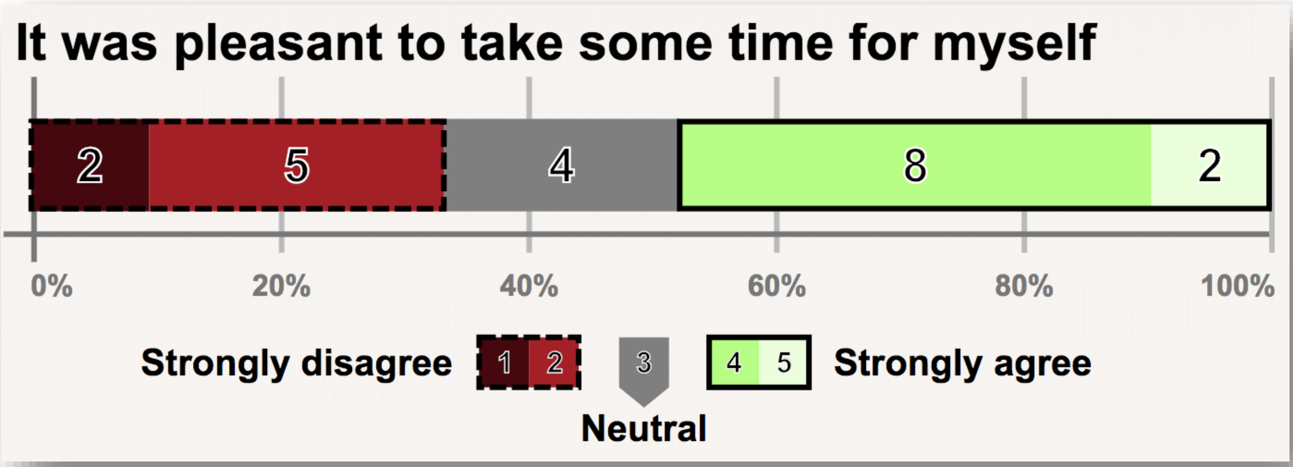


Figure 29 - Answer to statement: "It was pleasant to take some time for myself when the app was beeping".

Statement 5: When the app was beeping, my tendency was to follow the advice and go for a walk

Like statement 4, statement 5 is fragmented and all the Likert scales are present in the result. 47.6% of participants (33.3%+14.3%) agreed with the statement. 23.8% of the responders were indifferent while 28.5% disagreed.

These numbers were somewhat expected since for some employees it can be easier to interrupt a task and go for a short walk and for some other employees it might require more willpower.

This last statement might find its answers in the previous statements since an employee could find it difficult to stand up and move while he/she is in the middle of a task because this is felt as something that reduce productivity or focus.

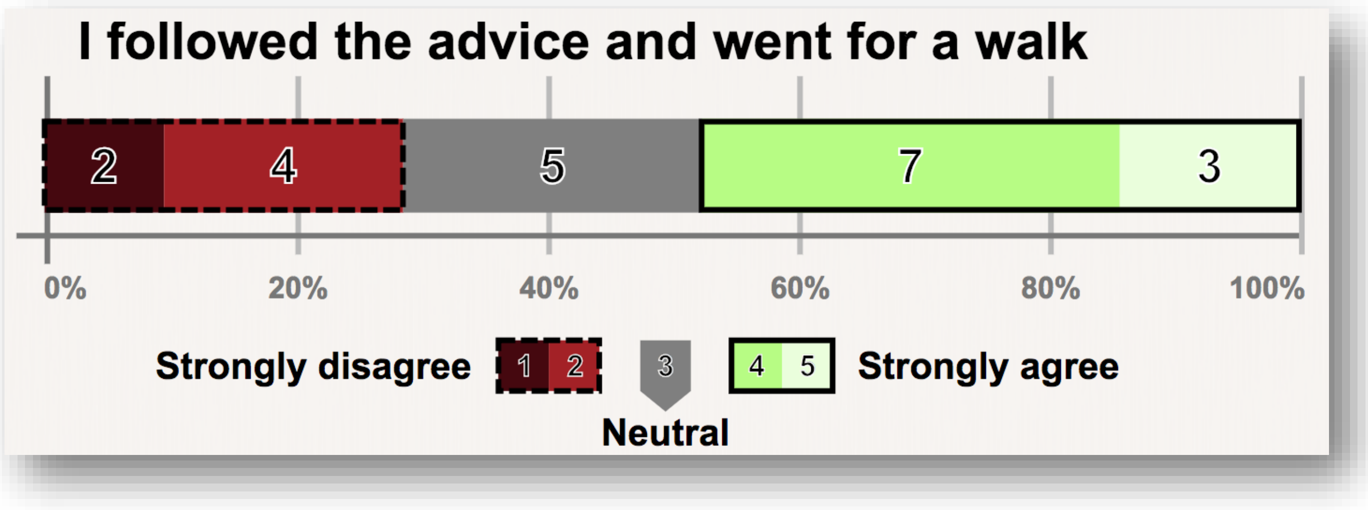


Figure 30 - Answers to the statement: "When the app was beeping, my tendency was to follow the advice and go for a walk".

Overall, JITAI Walk app was well accepted. All employees (100%) stated that the app was easy to use and manage during the intervention week. Surprisingly, most employees stated that they would use the app even after the experiment ended and the experimenter got informed from some employees that they are actually still using the app.

In regard to productivity, 85% employees stated that using the app during the intervention week didn’t make them less productive or less focused. As expected, when the app was beeping when an employee did not make enough steps, there was some resistance in stopping the current task and go for a walk.

Between quantitative and qualitative results, it can be stated that the app was an element of success for JITAI Walk. Some of the discoveries from the data analysis deserve further discussion, which will be developed in the discussion chapter.

CHAPTER 7. DISCUSSION

The initial hypothesis was that a JITAI could effectively increase physical activity of employees in office settings.
This hypothesis is in line with hypothesis from other JITAIs whose aim was to increase physical activity although not at work.(4)(5)
In line with the hypothesis, my findings from the experiment showed that the JITAI Walk app is capable of increasing walking among office workers. Results are comparable with outcomes from similar successful interventions.(4)(5)

These findings have great importance since only few JITAI have been designed for the specific problem of increasing physical active at work. At Novo Nordisk, this is the first time a JITAI intervention was carried out to increase employees' physical activity at work.

Salient points of the JITAI Walk design are now discussed.

Employee sample and type

Employees were eligible if they were at work during the baselines and intervention weeks. Due to dropouts, only 21 employees were eligible for data analysis. A bigger sample size, for example including a full department or even a division (around 500 employees) would definitely be more effective in trying to understand employees' behavior and thus, to design a better JITAI.

Unfortunately, gathering a large sample requires a lot of coordination with employees prior, during and after the experiment. Time was a major barrier to the sample size.

Every employee involved in the experiment was a "knowledge worker". Expanding the JITAI to employees working different type of jobs (i.e. physical workers) would give to the company more insights on which jobs/tasks are too sedentary and thus, implement corrective actions to increase physical activity.

Tasks within the employee in the group were similar. Employees' activity level, defined by step counts, varied from a minimum of 5255 steps/week to a maximum 25689 steps/week. Such a difference in steps might be because some employees already had the habit of taking active breaks and walk.

Since the implementation of JITAI Walk, employees increased their physical activity by introducing walking breaks every 30 minutes. This period was decided by considering the results obtained from Yates et al. 2015 on behavioral reallocation, which have shown that reallocating 30 minutes of sedentary time into light-intensity physical activity was associated an 18% increase in insulin sensitivity. (6)

Intervention type and duration
The intervention lasted, like the baseline week, for 5 days.
This type of design was used because employees in the team would not commit for an experiment longer than 5 days as, due to external reasons, there was a lack of resources in the department. Furthermore, in a recent review from Shrestha et al., it

was found that the majority of the studies aiming at reducing sitting at work are short interventions lasting up to 3 months with the majority of the interventions lasting 1 work week. (7)

A longer intervention of at least 12 months, would be beneficial to assess if JITAI Walk app would be effective on the long time. Future studies should also have a control group to enable a more robust experimental design. This hypothesis is supported by findings from Clemes et al. concluding that longer interventions allow understanding better workers behavior and thus, designing better interventions. (8)

App design

First, it is important to underline that data was never collected externally from the iPhones and it was only used for steps calculations. Furthermore, real time data analysis was never (and it should never be) intended as surveillance of employees' daily activities.

JITAI Walk app was designed to be easy to use and to require minimal interaction with employees.
Qualitative data showed that this objective was reached but some improvements were also suggested.
The first improvement is related to the manual starting / stopping of the app every day during the intervention week. Two employees suggested to make this procedure automatic, the app could start automatically at 8:30 every morning and it could automatically stop at 16:30 every afternoon, thus further minimizing employee interaction.

The personal threshold defined for each employee when starting the app for the first time, was calculated by accessing the cache of the motion coprocessor. Motion cache in the iPhone can be accessed up to 1 week in the past. For the sake of the experiment, a timespan of 1 week in the past was considered to be enough but for general use, it may lead to errors as the previous week might be a special week, example holidays and thus, the number of steps would differ from a normal working week.

By retrieving data from the local iPhone Health database (HealthKit) it is possible to retrieve data from the whole year and, by applying ad hoc machine learning algorithm, the personalized threshold could be more representative of the employees' walking pattern.

In JITAI Walk app, data was only stored locally. In future versions of the app, data could be sent to a cloud database in order to include in the JITAI design other devices such as computers or other external sensors.
For example, if the app establishes that an employee has been too sedentary, notifications could be sent to both mobile phone and computer, prompting the employee to go for a walk.

Device choice

Apple iPhone was the device of choice because Novo Nordisk provides it to every knowledge employee. Furthermore, as shown in chapter 4, iPhone is a suitable device to be used in a JITAI design.
Since no other device was needed, experiment costs were kept to a minimum.

Using a mobile phone for a JITAI design requires employees to constantly carry the device. In different occasions, employees reported to have forgotten to carry the iPhone with them, for example when going to the toilet or when going to the printing room.

To mitigate this risk, smartwatches could be used instead. In fact, it is possible to convert the code used for the iPhone app into, an Apple Watch app or other smartwatches or fitness watches which have been proven to be reliant devices (9)(10).

Smartwatches are ubiquitous by nature since they are fixed to the wrist. Using smartwatches would give a more precise picture of employees' motion pattern. In fact, it is believed that the increase in steps is due, marginally, to the fact that during the intervention week, employees got used to carry the phone more often.

It comes without saying that the main reason why smartwatches were not used in this JITA is lack of resources. No smartwatches were available so a more cost effective solution has to be developed.

Employee reaction to notification

Even though employees walked more because of JITAI Walk app, the reactions to the notification were diverse. In particular, 29% of the employees stated that their tendency was not to go for a walk when a notification was received (see chapter 6.2). This behavior is believed to be somewhat normal and three main reasons have been identified.
The first reason is related to work performance. Since performance is related with bonus and increased prestige, tasks execution within deadline has priority. Employees gave more importance to task accomplishment (and performance) versus breaking sedentarity. To overcome this challenge, productivity techniques such as the "Pomodoro technique" (25 minutes of work, 5 minutes break) (1) could be used in order to ensure that a task gets done within deadline and that breaks are always respected and used to break sedentarity bouts.

The second main reason is lack of awareness. In accordance with literature, (see chapter 3.1) most people tend to make an error when estimating their physical activity levels (11)(12)(13).For this reason, employees that overestimate believe to be more physically active than they actually are, and they are prone to ignore notifications from the JITAI Walk app. The same can happen with employees classified as "active couch potatoes" (see chapter 3.2). If employees are moderately/vigorously active outside work, they tend to think that they do not need to move more during office time and thus, they too would ignore JITAI Walk notifications. A solution could be to make employees aware of the risks of sedentary behavior even if daily physical activity guidance is met.

The third reason, and perhaps the most important of all, is the lack of motivation to change. The education level of the employees taking part in the experiment was high (university level) and 19 out of 21 hold scientific degrees within health, pharmacy or biology. Despite the background, employees tend to spend most of their time sitting and this could be due to a missing association between increased physical activity and associated health benefit.

In behavioral psychology, the reason to change is also defined as “anchor” (2). When the correct anchor is identified, the person is much more likely to change a behavior (2). In JITAI Walk, anchors were used marginally and the generic reason of “getting healthier” was not enough to trigger an individual behavioral change.
This is confirmed by the fact that, after the use of the app, employees have verbally declared to walk less than before.
For this reason, deep focus has to be invested in developing notifications that are associated with employees’ feelings and are effective in changing behavior.
Since motivation plays a key role in behavior change, it is important to involve behavior scientists in the experiment design and mobile application development. (14)

These four reasons and their related suggested solutions can be added as additional content to future versions of the application. Furthermore, individual interviews with behavioral scientists can be implemented prior to the experiment. The latter option has been shown to be particularly effective for changing behavior in situation of resistance. (3)

Conclusion

In conclusion, the results of JITAI Walk show that it is possible to design low cost interventions such as JITAI for increasing walking at work. Although smartwatches will be the preferred solution in future studies, smartphones (iPhones) have been proven a reliable tool for delivering interventions remotely to employees only when needed. JITAI Walk app was well accepted by employees because of its simplicity and because it had no declared effect on productivity.

The preliminary nature of JITAI Walk warrants further investigation to clarify the effect of this type of interventions in office settings.

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CHAPTER 8. APPENDICES

A- Screenshots JITAI Walk

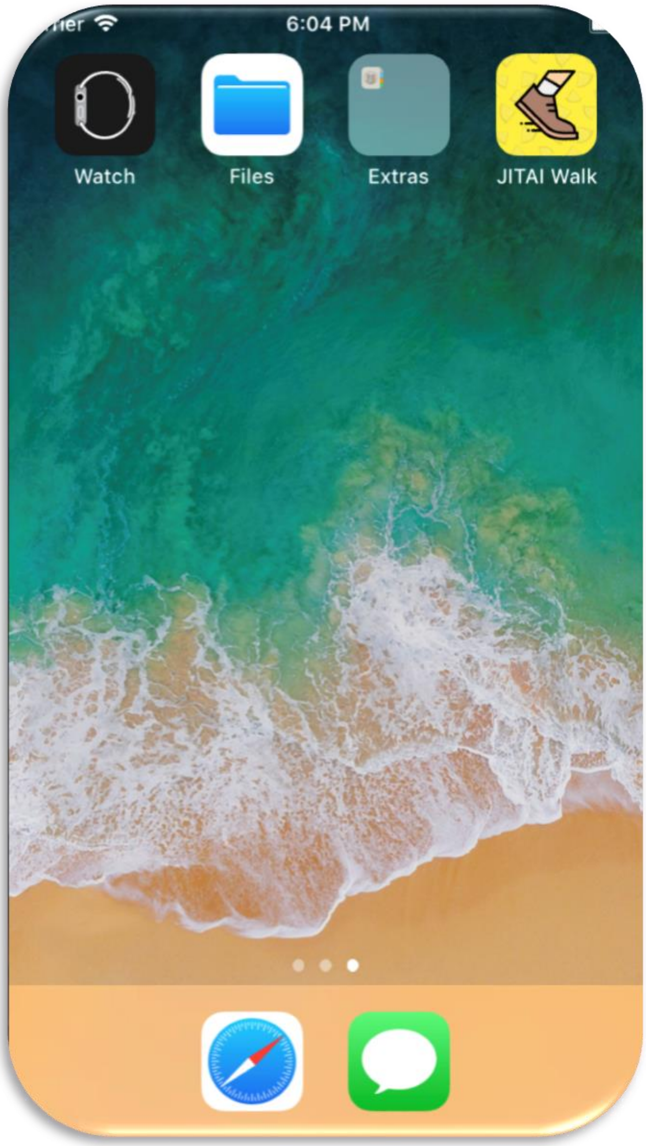

Figure 31 - Home screen view.

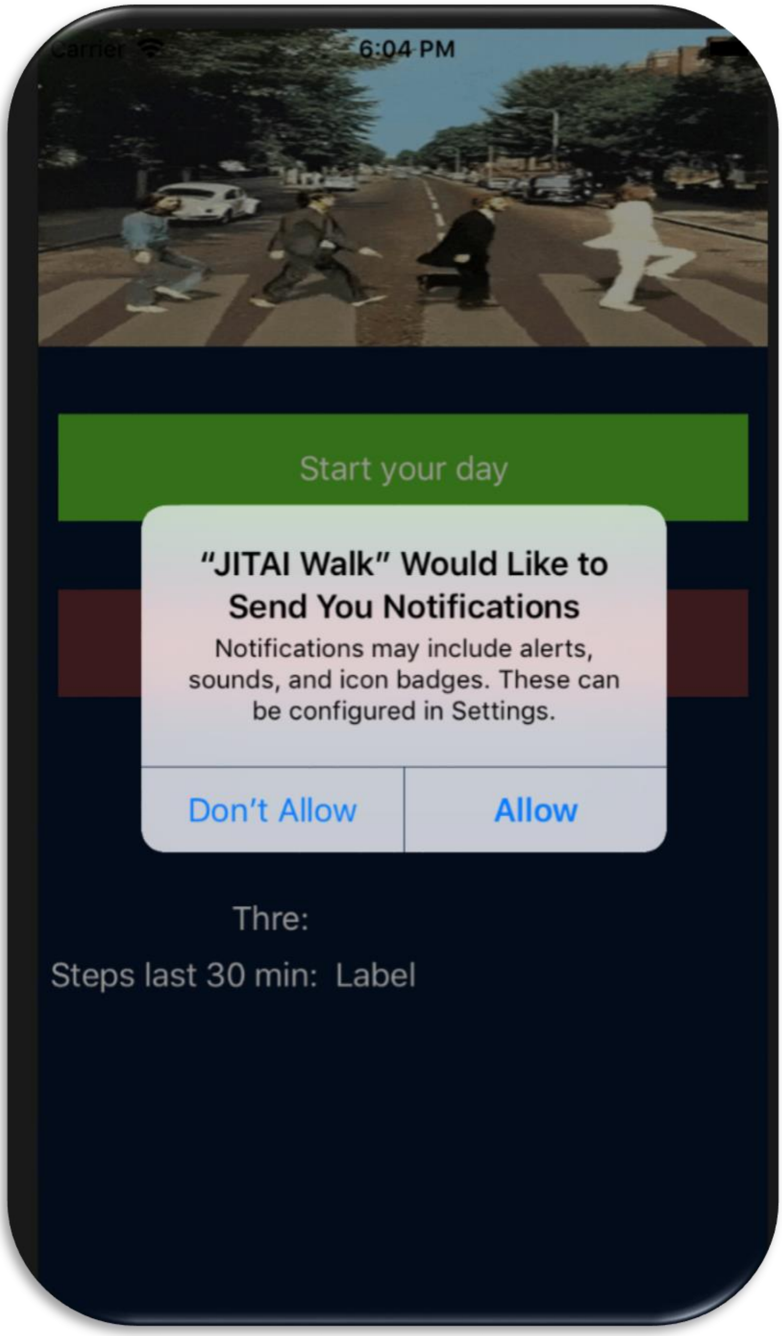

Figure 32 - App requests permission for sending notifications

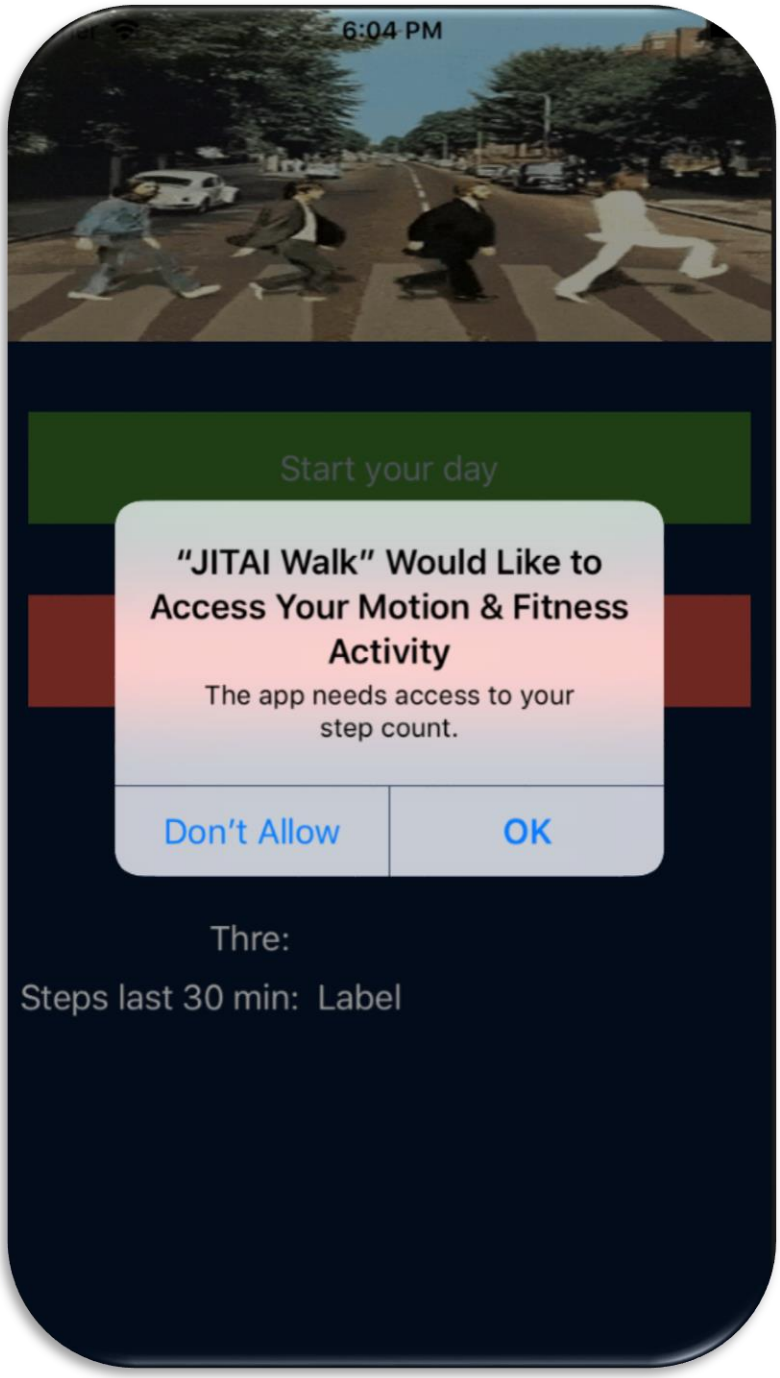

Figure 33 - After pressing "Start" the app asks s for access to fitness data

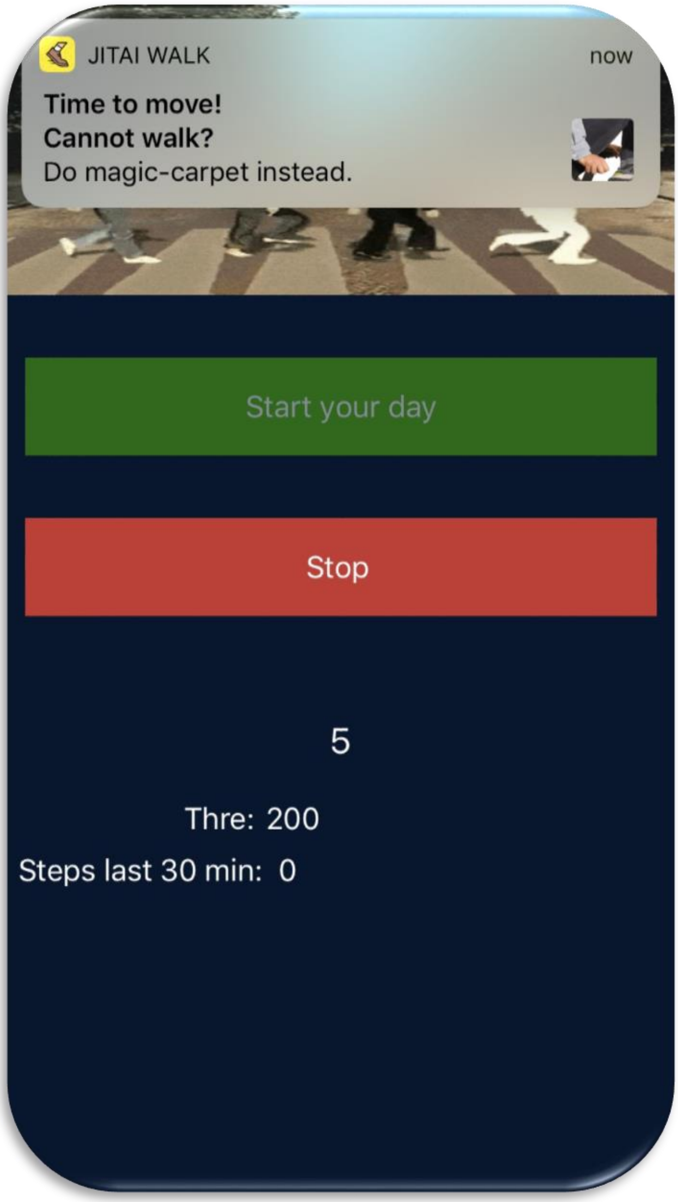

Figure 34 - Example of notification to help employees work more

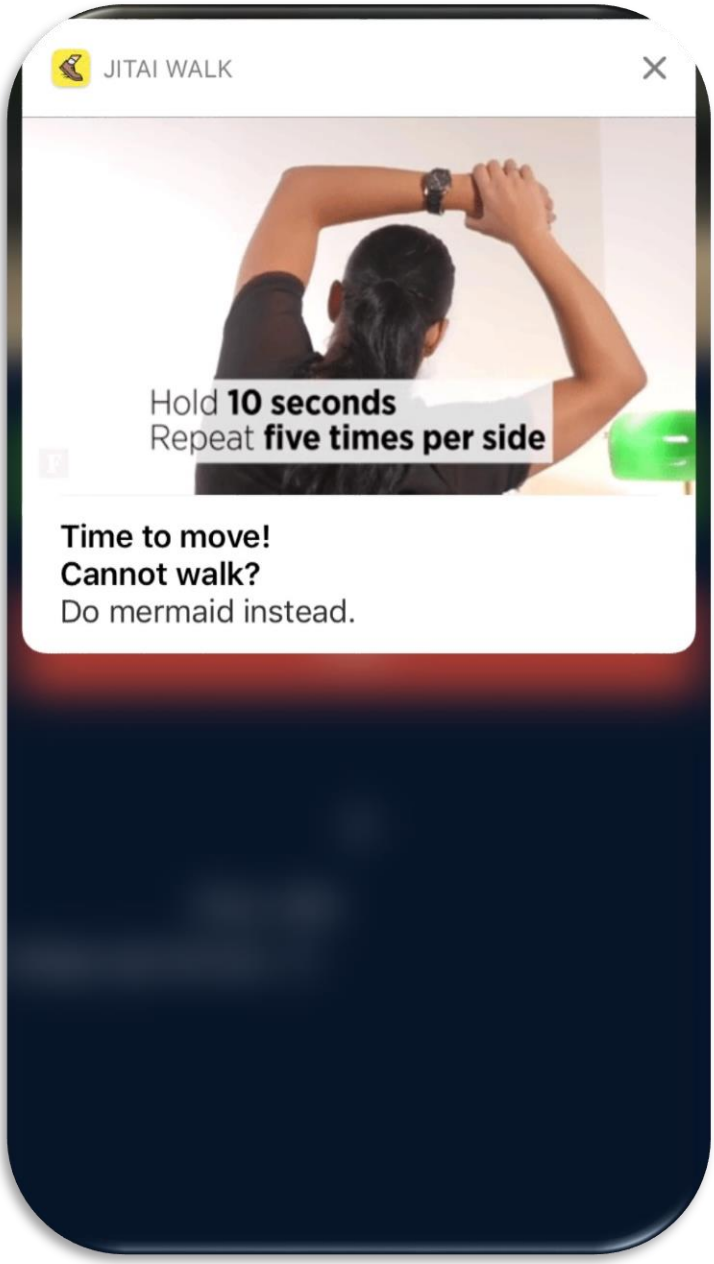

Figure 35 - When the notification is opened the alternative to walk are shown

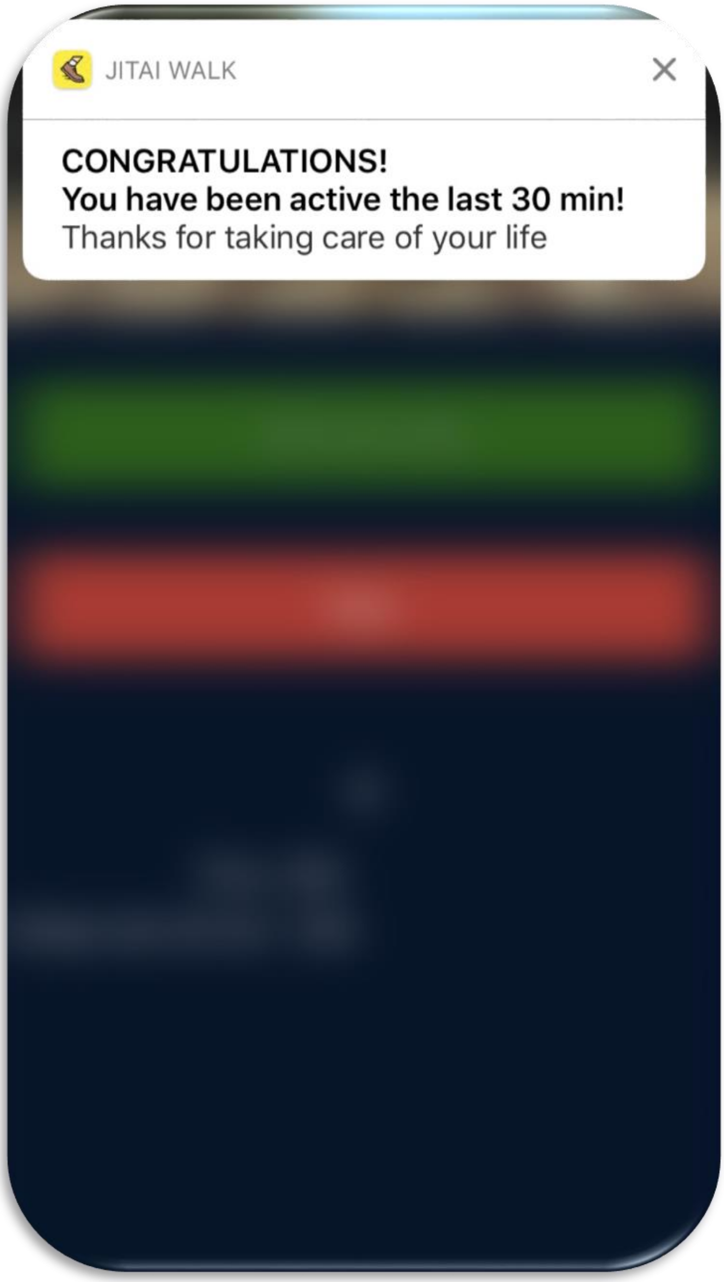

Figure 36 - Notification of accomplishment when employees have been active enough

Appendix B – Invitation to participate

Invitation to participate https://goo.gl/oorV1L

Appendix C - Questionnaires

Questionnaire productivity: https://goo.gl/forms/YG7vdUeGHIMJ4I9G3

Questionnaire app usability: https://goo.gl/forms/83m2L1n0Nyg58csa2

Appendix D – Statistic

All the files in the SPSS statistical files can be accessed here:

Dataset (SPSS file):
https://drive.google.com/open?id=1rDJ4z0clp_o8U63JUMHcUBIHUCwAJZXd

Normality Test. Shapiro-Wilk (SPSS file):
https://drive.google.com/open?id=1oS_rTEHc-EcbwlD37OaV6ueOREuGZnNs

Wilcoxon rank test (SPSS files):
https://drive.google.com/open?id=1hk5Uw5Js8I9xaradSZnWHABcjqRnqnl4

https://drive.google.com/open?id=1l3W3qI_ym9HcTqfOUhywlIpozmBWdT3z

Interquartile range, median and percentiles (SPSS files):

https://drive.google.com/open?id=1Rvc7lNcuuTubWI7_peq3BrfVtepG0o9z

https://drive.google.com/open?id=1e93wrrorTcLBxgIR4hKyHpayedFN9BZi

Appendix D – Source code JITAI Walk app

The source code for all the files of the app JITAI Walk can be accessed here:
https://drive.google.com/open?id=1xDzhPmUlAlCUnjfq0TILQ-v8HLNK3d49

Appendix E – Source code getSteps app

The source code for all the files of the app getSteps can be accessed here:

https://drive.google.com/open?id=1ueWBPkaWrqCtZLxvZlCACKXFElBAub3C