Promoting
PHYSICAL WELLBEING
In the Workplace

Michal Adar
Master Thesis

TUDelft

Promoting Physical Wellbing in the Workplace:

Providing Working Adults with a tool to reduce their sedentary behavior at the office

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EXECUTIVE SUMMARY

Today, humans are spending increasing amounts of time in environments that not only limit access to physical activity but also promote sedentary behavior. Whether it is at work, at home, in transportation, or in our communities, all of these environments have been designed in a way that minimizes human movement and muscular activity. This phenomenon is growing on a global scale and has become a great area of concern, as research has proven that prolonged sedentary behavior is linked to an increase in all-cause mortality.

The Effects of Sedentary Behavior

Physical inactivity accounts for 9% of premature mortality and as the sedentary lifestyle has become more prevalent many health risks have risen:

- Elevated incidences of cancers
- Increased musculoskeletal disorders
- Higher blood sugar levels and risks of type 2 diabetes
- Increased risk for cardiovascular diseases
- Increased risk of depression and cognitive impairment.

The Working Adult

This behavior is most prevalent among desk-based working adults in high-income countries as they often experience more prolonged, uninterrupted periods of static sitting as well as fewer briefs bouts of light-intensive activity during work hours. For this reason, workplace interventions for sedentary behavior are becoming an important area for intervention.

Employers Taking Action

The workplace is changing and the mental health and burnout epidemics have been deemed "occupational phenomenons" resulting in an explosion in the demand for employers to take action in promoting the wellbeing of their employees. One of the ways employees are attempting to do this is by reducing the sedentary behavior of their employees through the implementation of sit-stand desks in the office. These types of interventions have proven to be beneficial to both the employee and the employers as decreasing the sedentary behavior of employees has been proven to reduce health care costs, increase wellbeing, and decrease the number of sick leave days.

The Benefits of Sit-Stand Desks

Sit-stand desks are height-adjustable desks that allow the user to easily alter between the sitting and standing positions while working. They are considered one of the most popular methods used by employers to reduce their employee's sedentary behavior as they also have an array of physical and psychological benefits.

- Reduce musculoskeletal discomfort
- Lowers risk for cardiovascular diseases
- Reduces risk of weight gain
- Lowers blood sugar levels and risks of type 2 diabetes
- Improves mood, productivity and energy levels.

The Problem

Although the benefits of using a sit-stand desk have been recognized and companies are increasingly installing these desks in their offices, several studies indicate that there is a generally low utilization among working adults. One study even suggested that 60% of its participants chose not to use their sit-stand desks as they could just not be bothered.

Design Research

The above-mentioned studies raise many questions about why this lack of utilization occurs and how this can be changed. These questions are answered in this report through 11 in-depth interviews with both active and non-active sit-stand desk users. These interviews allowed for a better understanding of the current context as well as the different facilitators and barriers these working adults face when using their desks.

Design Goal

Participants provided many reasons for why they don't use their sit-stand desks, but the main reason is that sitting is just a habit that has been normalized in the workplace over past decades. The goal for this project is to change this view and alter the workplace norms so that transitioning between sitting and standing can become normalized. By focusing on the differences between the non-active and active users, several design opportunities were formed

- Increase awareness of effects of sedentary behavior
- Promoting social support among coworkers
- Increasing body & mind awareness

The Final Concept

To reach the final concept an iterative process of brainstorming, building, and testing was used. The final concept, BMDesk Application, and Controller, use habit formation techniques to enable working adults to become more intune with their body & mind. By becoming more self-aware of how they are feeling, the goal is that users can use their own body cues (e.g. discomfort or fatigue) as indications for when it is time to alter between sitting and standing. Through the concept, users will learn how to take a moment from their workday to check in on themselves and use personalized tips (provided by the application) to feel better and optimize their workplace practices.

Promising Results

A proof of concept where the BMDesk App and Controller are evaluated against the requirements set in the "Design Focus" was done to determine whether it meets the design goal. To accomplish this task, the final concept is tested upon the notions of desirability, viability, and feasibility.

Desirability: Do users believe that the concept contains the tools necessary to aid them in reducing their sedentary behavior at the workplace?

Viability: Are users willing to pay for the product or request it from their employer?

Feasibility: Can a working prototype be made?

Although more measurements are needed and iterations on the final concept should be done, the results of this test proved to be relatively positive. A majority of participants indicated that they would be interested in receiving this product from their employer as it could contribute to the decrease of their sedentary behavior and better workplace practices.

Overall, the BMDesk Application and Controller shows the potential to reduce the long-term sedentary behavior of working adults. Many additional ideas were created to improve upong the final concept and these are presenting in the recommendations section of this report.

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INTRODUCTION

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In our world today, sitting has become associated with a large portion of our daily activities. Whether it is while at work, socializing with friends, or just relaxing, sitting is often involved and even desired. But as all of our environments are becoming (re)designed to promote this behavior, the sedentary behavior that occurs due to these prolonged periods of sitting is harming the human body. The human body is meant to move and to reduce these adverse side effects of sedentary behavior, there needs to be a change.

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ABOUT THE PROJECT

Desk-based work has been around for centuries and although the physical workspace has changed and been modernized, it is still mainly comprised of a desk and a chair. But as the workspace has changed, so has the type of work being done. Over the past decades, globalization and technological changes have favored a progressive switch from physically demanding tasks to knowledge-based work (Panahi & Tremblay, 2018). This has resulted in a shift in the activity profile of individuals as physical activity has been replaced with cognitive work and there is a significant increase in our environments being (re)engineered for sedentary behavior. This increasing rate of sedentary behavior has emerged as a critical area for intervention, as prolonged sitting is proven to be correlated to an increased risk for adverse health effects such as cardiovascular diseases and musculoskeletal discomfort (Altenburg et al., 2019).

This behavior is increasingly apparent in the workplace. Today, jobs are becoming less and less active with recent studies indicating that employees spend almost a third of their lives in the office and about two-thirds of that time sitting (Finch et al., 2017). With the average working-age adult in high-income countries sitting about 9.3 hours per day, combing both work-time and leisure-time, sitting has been deemed the "new smoking," and this lack of physical movement results in adverse effects on health, wellness, and employee state of mind (Daum, n.d.; Mantzari et al., 2016). In recent years, prolonged sitting in the workplace has become a prevalent topic of discussion with many new developments meant to promote an overall health-enhancing work experience. One of these developments is the implementation of sit-stand desks. These desks allow employees to alter their position throughout the day, limiting any static standing or sitting. But despite their initial enthusiasm, research indicates that working adults often do not use the sit-stand desks, and wind up spending more time sedentary than they initially intended (Straker et al., 2013). This project looks deeper into the practices and habits of working-age adults to understand why this lack of use occurs and how it can be changed.

Problem Definition

Sitting is a habit and although companies are increasingly implementing new practices in the workplace aimed at reducing this behavior, working-age adults lack the motivation to adjust their static workplace behavior for a more active one. The target group is often surrounded by coworkers and peers who take on this behavior as well, resulting in a workplace environment where standing is not normalized and working adults often lack the additional knowledge and support to create this behavior change.

The Assignment

There are currently very few products on the market that are aimed at promoting the use of the sit-stand desks and changing posture throughout the workday. The products which do exist are often only compatible with specific electrically adjusted desks and will not benefit working-adults who already have access to the sit-stand desks at their place of work.

The goal of this assignment is to design a solution that provides the tools to support and encourage working-age adults towards utilizing the sit-stand desks and reducing their daily sedentary behavior.
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PROJECT STRUCTURE

The structure of this graduation project follows an agile design approach based on a cyclic process of analyzing, designing, building, testing, and refining the product. Through this process, the project is broken down into smaller stages.

Analyze

During the analysis phase, desktop and user research provides a better understanding of the current context. Five topics are investigated: (1) Sedentary Behavior, (2) The workspace (3) Sit-Stand Desks; (4) The Working Adult, and (5) The Market.

The analysis of these topics and outcomes are used to determine the design direction for the project and establish the design boundaries.

Define

The design direction is based on the key insights formed as a result of the analysis. This section summarizes the current context, establishes the design opportunities for the desired future, and provides the criteria and boundaries for the project.

Design & Build

During this phase, all of the knowledge developed through the research helps to create three initial ideas. These three ideas are tested and evaluated, and the best features from each are combined to form the final concept design. In the agile design process, there are several stages of designing and building.

Test

The final concept is evaluated against the design criteria, and its desirability, feasibility, and viability are verified. This is done through the creation of a prototype and design goal evaluation with users.

Refine

The final stage of the project takes all of the information gained from the evaluation and uses it to provide recommendations on how to move forward and improve upon the final concept.
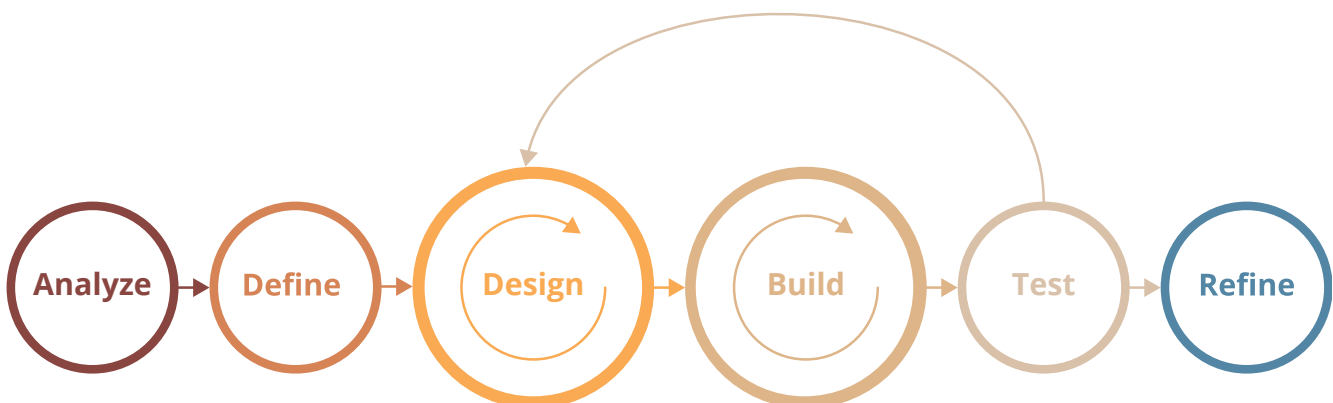
Figure 1: The Agile Design Process.

Beautiful,
free photos.

Tivoli Audio

ANALYSIS

UNDERSTANDING THE CURRENT CONTEXT

02

SEDENTARY BEHAVIOR

THE SEDENTARY LIFESTYLE

A sedentary lifestyle is defined as a lifestyle that involves little to no physical activity combined with prolonged periods of sitting or laying down. Almost all of the environments we encounter today are designed to limit physical activity and promote sedentary behavior. Whether it is at work, at home, in our cars, or around our nities, spaces have been (and continue to be) re-engineered in ways that result in humans moving less and sitting more (Owen et al., 2010). Seated activities have become a subconscious norm associated with times of socialization, productivity, and relaxation and have been identified as being part of a person's "self-image" (Rawlings et. al., 2019). But, from an evolutionary perspective, humans were designed to move and the human body works best when it is active. This transition away from a physically active lifestyle towards a sedentary one has put the human body at a greater risk as sedentarism has been proven to be associated with all-cause mortality (Malina & Little, 2008; Panahi & Tremblay, 2018).

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Sedentary Behavior & Physical Inactivity

According to the World Health Organization (WHO), adults should engage in a minimum of 150 minutes per week of moderate-to-vigorous physical activity to help prevent and manage multiple chronic conditions. Non-exercise behaviors can be differentiated into two categories: light-intensity activity or physical inactivity and sedentary behavior; and it is important to understand the distinction between these categories.

Physical inactivity refers to performing insufficient amounts of moderate-to-vigorous intensity activity and the non-achievement of the physical activity guidelines: 150 minutes, or 2.9 METs or less (Thivel et al., 2018; Panahi & Tremblay, 2018).

Sedentary behavior represents any waking behaviors characterized by an energy expenditure of ≤ 1.5 METs, while in a sitting, reclining, or lying posture (Thivel et al., 2018).

Sedentary behavior is distinct from physical inactivity because even if adults meet the physical activity guidelines, they can still be subject to the deleterious biological consequences due to unbroken periods of prolonged sedentary time (Owen et al.). This means, that even if an adult bikes to work or goes to the gym every day if they spent their entire day at work sitting, they will still be at risk for the adverse health effect caused by sedentarism.
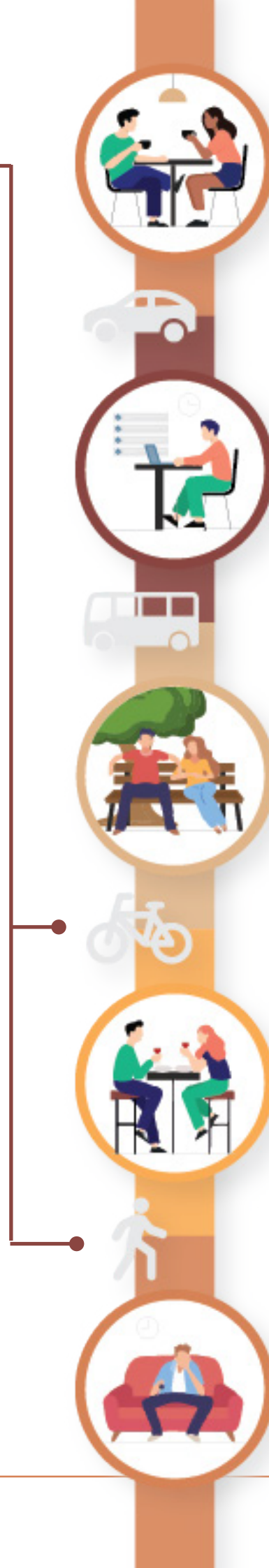
Figure 2: All environments are designed for sitting.

The Effects of a Sedentary Lifestyle

As mentioned in the previous section, the sedentary lifestyle has a major impact on the health of the global population. Physical inactivity accounts for 9% of premature mortality worldwide and is considered the fourth leading risk factor for global mortality (Panahi & Tremblay, 2018; Park et al., 2020). Although sedentary behavior poses a comparable risk to health, most interventions are focused on improving physical activity rather than reducing the time spent in a sedentary position. As the sedentary lifestyle is becoming more common, many health risks have risen. In addition to the increase in all-cause mortality, prolonged periods of sitting have resulted in raised risks of cardiovascular disease, cancer, metabolic disorders such as diabetes mellitus, hypertension, and dyslipidemia; musculoskeletal disorders, depression, and cognitive impairment (Park et al., 2020). Therefore, reducing sedentary behaviors is important to promote the health and general well-being of the global population

Taking Breaks from Sitting

Studies have shown that by breaking up sedentary time with standing, walking, or other light-intensity activities there are beneficial associations that counteract the adverse effects of prolonged sitting. These benefits include a reduction in musculoskeletal discomfort, lower risks of cardiovascular diseases, an increase in metabolism and blood flow, greater muscle activity and energy expenditure, lower blood sugar levels and risk of type 2 diabetes, as well as improved mood, productivity, and energy gain (Agarwal et al., 2018; Chastin et al., 2015; European Society of Cardiology, 2018; Doyle, 2016; Garrett et al., 2016; New Balance Associates & Wellness & Prevention, 2012).
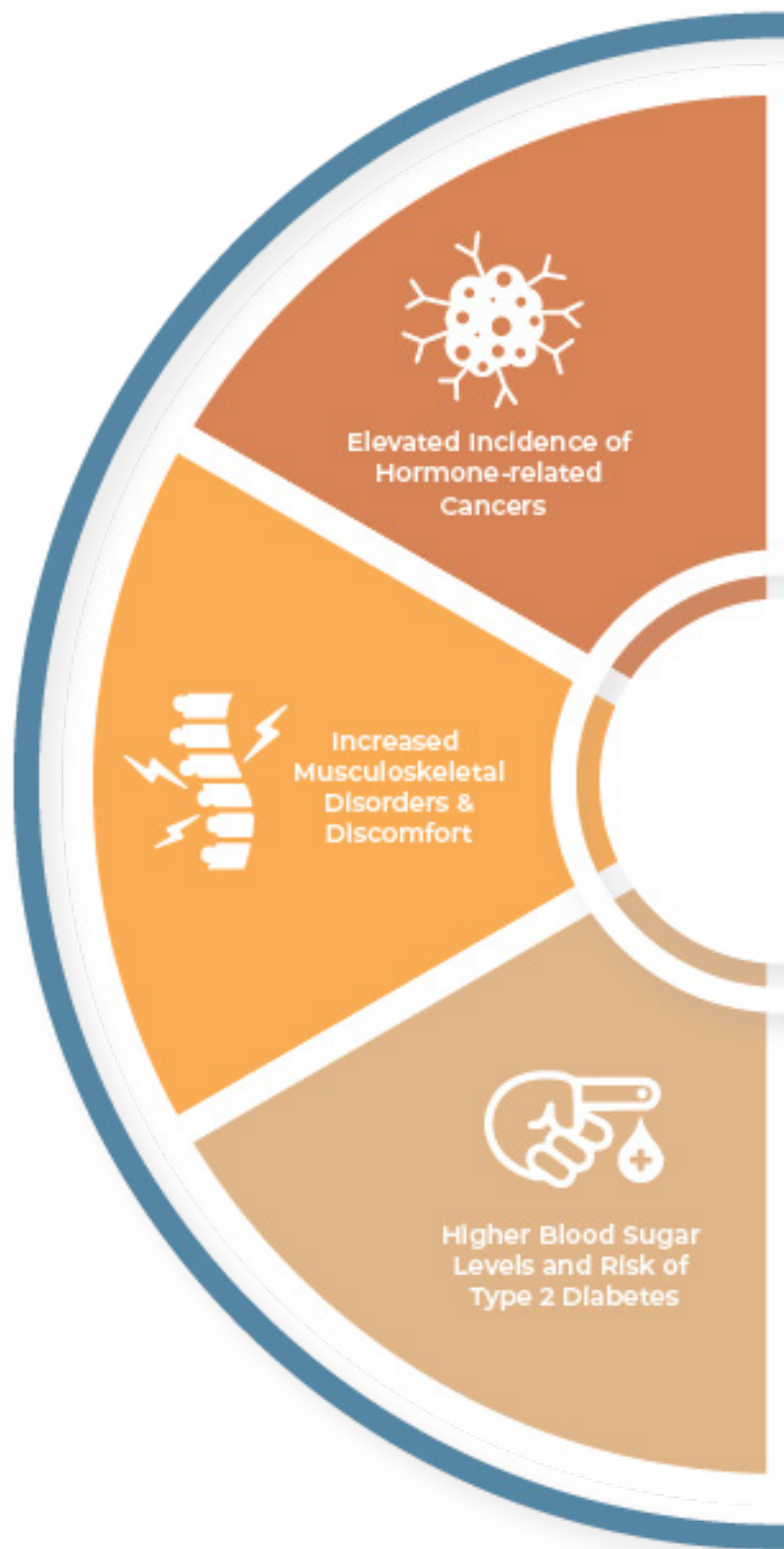
Figure 3: The Negative Effects of a Sedentary Lifestyle

Sedentary Life and The Workplace

The rise in sedentary behavior is increasingly apparent among desk-based working-age adults in high-income countries. With the average working-adult sitting about 9.3 hours per day, these individuals are proposed to be at greater risks for the poor health outcomes associated with sedentarism (Daum, n.d.; Mantzari et al., 2016). According to an article published by BMC Public Health, office work was found to account for nearly half of working-age adult's weekly sedentary time. These individuals also experience more prolonged, uninterrupted sedentary time and fewer brief bouts of light-intensity activity during work hours compared to non-work hours (Parry & Straker, 2013).

For this reason, workplace interventions for sedentary behavior are becoming an important topic of discussion, with many employers proposing workplace physical activity programs meant to alter the sedentary nature of their employee's work. These types of interventions present benefits to both the employee and the employer as increasing the physical activity of employees has been proven to reduce health care costs, increase wellbeing, and decrease the number of sick leave due to diseases or injuries (Genin et al., 2018). Unfortunately, studies show that sitting and screen time remains relatively high, and brief periods of physical activity will not counteract the effects of the sedentary behavior that occurs at the office.

Increased Risk for Cardiovascular Diseases

This risk is greater among desk-based working-age adults.

Increased Risk of Depression and Cognitive Impairment
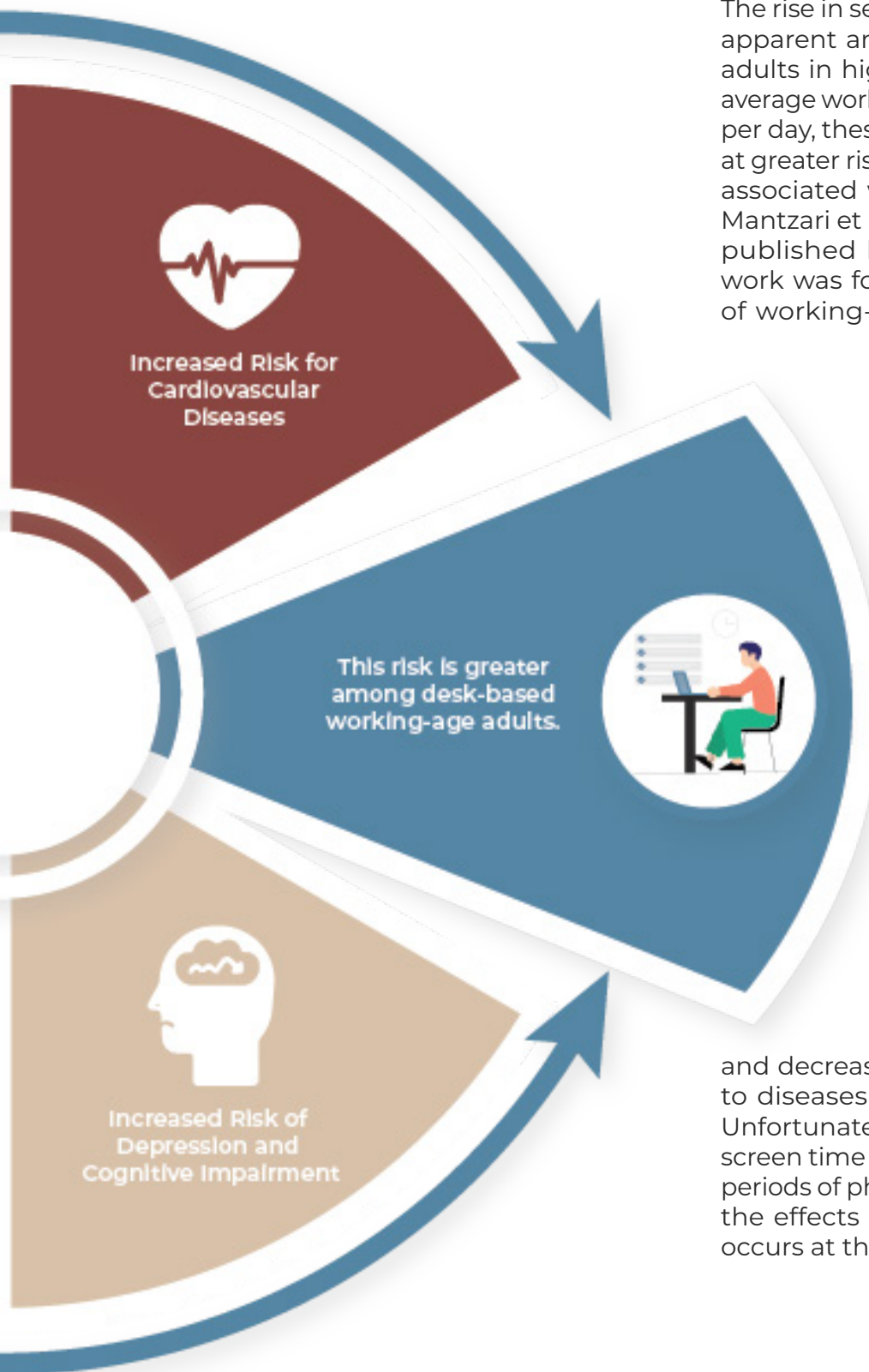
United States
1,767 hours/year

Germany
1,332 hours/year

United Kingdom
1,367 hours/year

Netherlands
1,399 hours/year

A Special Focus on the United States

As mentioned in the previous section, desk-based working adults in high-income countries are at a greater risk for sedentary behavior. This risk is even more prevalent among working adults in the United States as they are often considered to have a "live to work" mentality, believing that hard work is associated with success (Okulicz-Kozaryn, 2011).

According to the Organization for Economic Co-Operations and Development (OECD), in 2020 the United States was ranked 11th for average annual work hours, compared to the Netherlands, which was ranked 40th. Dependently employed Americans between the ages of 25-64 work on average 39.9 hours a week. This is 8.35 hours more than the average Dutch workweek (OECD, 2020). These hours do not include the commute to and from work, during which most Americans also spend sitting in their cars.

For this reason, the project will analyze working adults in high-income countries with a special focus on working behavior in the United States.

Figure 4 The average annual working hours of working adults in the United States, Germany, the United Kingdom, and the Netherlands.

Current Relevance

Covid-19

Since 2019, the outbreak of the COVID-19 pandemic has had a significant impact on workplace practices, forcing both employers and employees to rapidly adapt to stay afloat. Within these new circumstances, remote working has become the new norm and employees are beginning to trade in their commute time for more time spent working, and in turn, more time spent sitting. According to a survey done in the United States, four in five Americans are spending more time at home now and 74% of them finding themselves sitting an average of 4 more hours per day (Melore, 2020). These numbers correlate to a study conducted in the Netherlands which stated that despite a small increase in physical activities since the start of the pandemic, there has been a larger increase in sedentary time and a net reduction in habitual physical activity levels (van Bakel, 2021).

Although remote working and the increase in working hours have presented record levels of productivity, it has also resulted in a heightened mental health crisis and burnout epidemic among working adults (Schawbel, 2020; Schawbel, 2021). And as the everyday office is expected to transition towards a more hybrid environment, there is a risk the prevalence of sedentary behavior and its effects on both the mental health and physical health of working adults will continue to rise at an even more rapid rate.

Image Source: Photo by Tim Gouw on Unsplash

CONCLUSION: SEDENTARY LIFESTYLE

Sedentary behavior is increasing globally and has become a prevalent topic of discussion, with desk-based working adults considered high-risk. As this behavior is not expected to change without intervention, it is imperative to design solutions that aid working adults in reducing their sedentary time while in the office. Following the initial analysis of sedentary behavior, one key conclusion is formed:

Working adults may not be aware that their prolonged periods of static sitting can have a long-term negative effect on both their mental and physical health. As all environments are designed for sitting, sitting has become a norm both in and out of the workplace. In this case, this norm may be seen as an okay practice since everyone is doing it and there is a lack of education on the long-term side effects of sedentary behavior.

Working adults may not be aware that these effects are not negated by taking part in brief bouts of physical activity outside of the workplace. Often individuals believe that if they achieve the recommended amount of physical activity outside the workplace, this makes up for their relatively inactive workdays. In this case, these individuals are probably not aware that sedentary behavior is distinct from physical activity and even if they reach this recommended time, they are still at risk for the adverse health outcomes that correlate to prolonged periods of static sitting.

Boundaries

The long-term adverse health effects caused by a sedentary lifestyle may already be felt by many working-age adults who have worked behind a desk for a long time. The goal of this project will be to design a solution aimed at helping working adults reduce their sedentary behavior in the workplace in order to prevent these long-term effect, rather than designing to aid working adults who are already impacted. Based on the initial analysis of sedentary behavior and its prevalence in the workplace, the following boundaries are set:

1. The solution shall focus on prevention rather than intervention
2. The solution shall focus on reducing the sedentary behavior of desk-based working-age adults in high-income countries with a special focus on the United States.
3. The solution shall be usable during the workday and in the workplace

03
THE WORKPLACE

Over the past decades, globalization and technological changes have favored a progressive switch from physically demanding tasks to knowledge-based work resulting in a workplace where sitting behind a desk and staring at a screen has become the norm. Even as the workplace changes and becomes more modernized, this practice is expected to stay in place and even increase on a global scale.

As the long-term adverse effects of sedentary behavior are becoming more known, employers are beginning to take action to promote the well-being of their employees and aid them in developing better habits while at work. To best understand the working adult, it is important to first take a look at their office practices and the current workplace trends.

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THE WORKSPACE

Today, employers are becoming more creative with their office layouts moving away from the "cube farms" which were popular in the past. These new layouts are geared towards encouraging collaboration and fostering productivity and camaraderie among employees. Over the past twenty years, there has also been a shift away from a hierarchical office layout, where management is separated and placed in private offices, towards a more egalitarian workspace where management is treated the same as employees. The following section describes the different types of workplace layouts. Appendix II presents the pros and cons of each layout.

Cubicals

Cubicles are partly enclosed workspaces with high walls to separate each worker from those around them. They are commonly used in the United States, providing employee's with their own personal space and a sense of privacy. As the start-up industry becomes more popular and many companies do not have enough space to house cubicals for each of their employees, there has been a transition away from the cubical layout to that of an open office layout.

Image Source: (Office Furniture, 2021)

Confined Offices

Confined offices consist of closed-off office spaces that are often private or shared by two or three employees, depending on their hierarchy. These offices are connected by a long corridor and provide employees with a sense of privacy. Although these offices still exist today, many companies are shifting towards a more open-office style floor plan.

Open Offices

Open offices have become a popular layout consisting of employees working in a single room and either sharing tables or working at independent desks in an unrestricted space. As mentioned in the previous section, this office

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Image Source: Photo by Flo Dahm from Pexels

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layout has been popular in the start-up scene and many big corporations have adopted this design as well as is more affordable, provides flexibility, and encourages interaction and communication among all levels of employees. Although open offices are becoming the new norm, there are also significant disadvantages to their use resulting in a lack of privacy as well as an increased possibility of distractions.

The following sub-sections describe the various forms of open office layouts that are becoming more popular.

Hoteling / Shared Office

Hoteling, or shared offices, consists of a system of unassigned seating where employees frequently change workspaces. This is popular in companies where employees often work remotely and don't require a permanent workspace. This way they can shift based on who is in the office on a given day. As the trends on the next few pages show, as the office develops into a hybrid style of work, the type of office space is expected to become more popular as it saves money, encourages collaboration, and provides a change of scenery. This type of office space can also be seen as confusing as desks are shared and employees do not have their own space.

Co-Working Spaces

Co-working spaces usually involve a few people sharing an office or a desk. This space commonly adopts an open office layout while also creating a sense of compartmentalization for specific tasks and groups, rather than keeping each employee in a single space. Although the goal of co-working spaces is to provide a semiprivate and organized environment to foster collaboration, this layout can be distracted and may not be private enough.

Low Partition

The low partition office style provides a middle ground between the open office and cubical layout. In this office style, employees can speak to each other while also having a sense of privacy and control over their space

Home Office

The desire for a flexible work environment and the ability to work from home began several years before the start of the Covid-19 pandemic. But as this pandemic occurred, employers had to adapt to ensure their employees were able to get their work done from their homes. This ability for remote work is expected to continue with employees spending part of their time working from the office and part of their time working from home. But as the last year has proved, working from home has been found to limit collaboration and lack boundaries.

Image Source: Photo by Martin Katler on Unsplash

Conclusion: The Workspace

As stated in the previous sections, more companies are moving away from the cubical office and confined office style towards that of an open office floor plan that promotes a more egalitarian, collaborative and creatively engaging workspace environment. These open floor plans have essentially made cubicals redundant by proposing a space that is more affordable and flexible. There is currently much debate among researchers about whether this kind of workspace positivity affects the working environment. For this reason, the solution shall be design for the open-office floor plan but shall consider that this office style may be re-designed in the future.

Boundaries

The space that the final solution is designed for is a critical component of the design process and the following boundary has been selected to account for this:

1. The solution shall be designed for open-office layouts in which more than one employee is working in the same room.

What does this mean?

As the solution shall operate in the open office floor plan, it shall take into account that there is a lack of privacy and that space is shared between coworkers. In addition, the open-office layout generally has an egalitarian feel which means that there is less of a sense of hierarchy among employees.

TRENDS IN THE WORKPLACE

Over the past few years, the workplace environment has provided a constant and yet rapidly changing atmosphere. These changes have taken a leap since 2020, with Covid-19 forcing companies and their employees to quickly alter the way they work. By observing these trends, particularly those expected to progress into the future, a better understanding can be developed about working-age adults and how these trends may affect their practices and experiences in the workplace.

Digital Transformation

Since the beginning of the digital age, there has been a visible shift in workplace practices, transitioning from physical work to more cognitive work. This digital transformation has been a key driver, creating new forms of work while making others almost disappear. These digital technologies are interconnected with office work, providing support for the workforce, while also providing solutions that allow employees to work from anywhere they want.

This transformation has only excelled since the beginning of Covid-19, as employees were forced to work from home, and employers were required to adapt to a more digital environment to stay afloat. Previous to Covid-19, many companies were quite resistant to the implementation of new technologies, particularly those that support remote working, but due to the pandemic, at least 80% of leaders accelerated the implementation of technology resulting in a rapid digital transformation (Schawbel, 2020).

The Always-Available Workday

Due to the digital transformation of the workplace and constant access to mobile devices, the 9-5 workday has become the always-available workday. Covid-19 has even made this worse as employees are now working from home and the time they previously spent in transportation has now been altered with more working hours. On average, working-age adults have added 5 to 10 more hours to their workweek. Although this additional time spent working has led to greater productivity for the employers, it has also accelerated the current "burnout" epidemic which was deemed a national phenomenon in 2019 (Schawbel, 2020).

The Hybrid Workplace

For years now, employees have desired flexibility in the workplace. There is an unspoken trade-off between employers and employees that as long as employees are working more hours for no additional pay, employers need to provide employees with more control over where, when, and how they work (Schawbel, 2021).

Remote Work is Here to Stay

In 2020, flexibility became mainstream due to Covid-19. Employers were required to quickly adapt and provide a more flexible work environment. This trend is expected to continue into the future, as 84% of office workers in the United States say they want the option to work from home at least once a week when Covid-19 is no longer a threat (Schawbel, 2021). With the accelerated digital transformation, employers can no longer make an excuse to not provide this flexible work environment, particularly as it has been proven to be effective and can even save the employer's real estate costs (Schawbel 2020, 2021).

Work-Life Balance

As remote working becomes the new norm and the always-available workday is more prevalent, work and life are becoming blended and the idea of a work-life balance is more difficult to achieve.

Desire for Belonging

Since the start of the Covid-19 pandemic, employees have been working from home more often and there has been a lack of a sense of belongingness. This lead to the realization of the Loneliness epidemic in 2019, as loneliness became a global issue with so many people isolated in their homes. Before the pandemic, employees already wanted a sense of community from their workplace, and with the pandemic, this desire for belongingness has only increased resulting in the expectation of company leaders to build a culture that promotes community engagement (schawbel, 2020; 2021).

The Office is Here to Stay, Too.

Designed for Flexibility

The physical office will continue to play a role in the future, but it will be designed to support flexibility and choice. This will lead to companies rethinking the workspace and opting for co-working spaces and home offices to support increase and ongoing mobility (Garcia et al., 2021).

Image Source: Photo by tyukin.photo on Freepik

Image Source: Photo by ArthurHidden on Freepik

Image Source: Photo by vectorjuice on Freepik

Since the ability to work remotely is expected to remain in place, employers need to rethink the office space to provide employees with a venue for community, culture, and collaboration (Garcia et al., 2021). In this model, the office will become a base for structure and sociability with an emphasis placed on meeting people, co-creation, and providing employees with an on-site location to ensure continuous communication between teams (Boonstra, 2020). For this case, offices will remain intact as studies have shown that communication between people in an office increased exponentially the closer their desks were, and as the distance between team members increased, their communication decreased. This decrease in communication also means a decrease in meaningful interactions which limits the level of trust a team has when functioning (Levy, 2021).

Employee Health & Wellbeing

The workplace culture is changing and mental health, burnout, and loneliness epidemics have been deemed an "occupational phenomenon", resulting in an explosion in the demand for employers to take actions in promoting employee wellbeing both in and out of the office. The workplace wellbeing movement has become one of the biggest conversions especially as various acts concerning working conditions were coming into effect and people are becoming more health-conscious. This was further enhanced in 2017 when employers in the United States started using wellbeing programs as a key employee benefit as they recognized the importance of a healthy workforce to obtain success across their organizations (Schawbel, 2021). This correlates with the trend that employees are now prioritizing safety, security, and health over professional growth when evaluating employers (Schawbel, 2020). In this case, not only is the promotion of positive wellbeing in the workplace beneficial for employees but for employers as well. By having a better workplace culture, employees feel better and this helps them do better resulting in higher productivity and satisfaction

levels as well as a decrease in health care costs due to absenteeism and leave.

What is Wellbeing?

Well-being refers to an individual's ability to realize their own capabilities and be able to feel good and function well with the normal stresses of life (Abdin et al., 2018). The four dimensions of wellbeing: social, psychological, physical, and spiritual, offer a holistic view of our self-being and when employees report higher scores on more than one dimension of wellbeing, it is likely to yield positive outcomes for the employee, their community, and their organization (Alagaraja et. al., 2020). Figure 5 presents a further explanation of these four dimensions. However, worksite interventions can rarely address all four dimensions simultaneously, therefor Ryan et. al., 2021, states that workplace health and wellbeing interventions should target two key dimensions: physical and psychological. This is consistent with the World Health Organisation's definition of health (Ryan et. al., 2021). For this project, social wellbeing is also a key dimension for consideration as the final solution is bounded by an environment in which working adults often interact with their peers.

By improving upon the physical wellbeing of employees in the workplace, organizations increase their safety levels and there is a decreased risk of workplace accidents. Also, enhanced physical wellbeing allows employees to have good health and increased energy levels needed to carry out daily tasks. When psychological wellbeing in the workplace is high, it indicates the presence of both life and job satisfaction resulting in better job performance as well as healthier and happier workplaces. By improving upon social wellbeing, working adults can better connect and develop a sense of belonging in the workplace (Alagaraja et. al., 2020). As showing in Figure 5, the four dimensions of wellbeing are interconnected, and improving upon one dimension of wellbeing, is likely to enhance an employee's wellbeing in the other dimensions as well.

Improving Workplace Wellbing

Inner Wellbeing

Outer Wellbeing

Spiritual Wellbeing

Social Wellbeing

Psychological Wellbeing

Physical Wellbeing

The different dimensions of wellbeing are all connected, so by improving upon one, there will be a positive impact on the others:

Psychological Wellbeing	Physical Wellbeing
Self-Acceptance	Decrease in accidents
Positive Relationships	Increase in safety levels
Autonomy	Decreased Stress
Environmental Mastery	Decreased Aggressions
Purpose in Life	
Personal Growth	

Spiritual Wellbeing	Social Wellbeing
Connection with Others	Social Integration
Connection to Inner World	Sense of Belonging
Connection to External World	Interdependence
Purpose in Life	Collective Consciousness
Meaning in Work	Collective Fate

Figure 5: The four dimensions of wellbeing. Source (Alagaraja et. al., 2020)

Image Source: Photo by ThisisEngineering RAEng on Unsplash

Source: Trifocus Fitness Academy / Should you Replace you Office Chiar with an Exercise Ball?

Source: Freepik /Wavebreakmedia

Source: gostanding.org / 9 Best Under-desk Treadmills 20201

Source: TheStar / Cycling desk puts a new spin on homeworking under lockdown

Source: Flexispot / Electric Standing Desks: 3 Reasons you'll Never GO Back to Prank!

EMPLOYERS TAKING ACTION

As the demand for employee wellbeing explodes, employers are beginning to take action to provide their employees with tools meant to meet their needs as they prioritize safety, security, and health in the workplace. Companies are now partnering with wellness technologies and programs to scale to their workforces' mental and physical health needs as this benefits both the employee as well as the organization.

Physical Wellbeing & Reducing Sedentary Behaviors

One area in which employers are taking action is in the area of physical wellbeing and the desire to reduce the amount of time working adults spend in a sedentary position. As mentioned in the previous sections, sedentary behavior is increasing at a global rate, with working-age adults specified as a high-risk group, and the adverse health effects of prolonged sitting can affect both the physical and mental health of employees. To intervene in this behavior, employers have been offering their employees new means of altering their work habits. These include promoting walking or standing meetings and breaks, providing access to active furniture, and the installation of sit-stand desks.

Wellness programs and gym passes are also popular methods to encourage the physical well-being of employees, but these are aimed at promoting an increase in physical activity rather than at reducing sedentary behavior.

Standing Meetings

A stand-up meeting is a meeting in which all participants participate while standing. These types of meetings are becoming more popular in many organizations and are typically brief, daily progress sessions during which working adults provide updates and coordinate efforts.

The goal of these meetings is to both get users away from sitting at their desks and to keep meetings short as standing can lead to discomfort (Frisch, 2016). Research has shown that these types of meetings can boost group productivity, but they do not occur often enough to limit the occurrence of prolonged periods of sitting for individuals.

Walking Meetings

Walking meetings are meetings that occur in which all participants participate while walking. This is usually done outdoors to allow participants access to fresh air, provide them with a brief bout of light-intensity activity, and promote a collaborative way of working. Although these meetings are known to promote both the mental and physical wellbeing of employees, like the standing meetings, they do not occur often enough to limit the occurrence of prolonged periods of sitting. Rather, they are designed to encourage physical activity while working. Also, they are perceived to be more time-consuming compared to "normal" meetings, more difficult to plan as they are dependent on weather, and are conceived as inconvenient with larger groups of participants (Damen et al., 2020).

Walking & Standing Breaks

Walking and standing breaks consist of breaks taken by the employee from their work during which they chose to stand up from their desks and/or walk around. These

are beneficial for the working adult as brief mental breaks can increase productivity and reduce fatigue among other benefits (Harness, 2013). By including the element of walking or standing during these breaks there is an added benefit of reducing time spent sedentary. Unfortunately, the average adult already fails to take enough breaks during their current workday, as they often do not want to lose productivity, and in turn, they do not alter their sedentary behavior.

Active Furniture

Active furniture consists of furniture that allows you to work "in-motion" to reduce prolonged sedentary behavior and related degeneration phenomena (Probst et al., 2012). This kind of furniture includes exercise balls replacing desk chairs, bike workstations, treadmill workstations, and height-adjustable sit-stand desks.

Exercise Balls

Exercise balls, or stability balls, have become increasingly popular as an alternative to office chairs. The goal of implementing these balls to help reduce the prevalence of lower back pain by increasing trunk muscle. But, as several research studies have shown, the use of a stability ball does not greatly alter an individual's posture and at the same time, there is a greater contact area between the user and seating surface when comparing a stability ball and an office chair which results in increased levels of discomfort (Gregory et al., 2006). In this case, the magnitude of the perceived benefits is minimal compared to the reports of pain and discomfort, and the negative effects seem to outweigh the positive effects of sitting on a stability ball (Schult et al., 2013).

Treadmill Workstations

Treadmill workstations have been promoted as a means to increase physical activity during working hours. A study done by Hont et. al (2011) reported that office workers provided with a treadmill workstation, increased their walking time by 38-75 minutes per day. But due to the size and expense of the workstation, employers who purchase them for their

companies often place them in a space where they can be used by everyone. In this case, the workstation is only used by an employee for a brief period during the day. This may increase the amount of time spent in light-intensive activity, but if the employee reverts to periods of prolonged sitting during the rest of their workday, they are still at risk from the adverse health effects that come from sedentary behavior. Additional limitations of treadmill workstations are that they have the potential to limit productivity as stated by several research papers, and individuals who are overweight and obese are put at an increased risk for knee osteoarthritis and may have limited ability to walk (Elmer & Martin, 2014).

	Price
Treadmill Workstation	Prices range from about 500 USD for an under-desk treadmill to several thousand dollars for a full treadmill workstation with an attached desk
Cycling Workstations	Prices for a cycling desk with a built-in seat range from about 200 USD for a small folding version to well about $1,000 for a large stationary style.
Sit-Stand Desks	Prices range from a few hundred dollars for a desk converter to a few thousand dollars for the full electric adjustable desk.

Cycle Workstations

An alternative to the treadmill workstation is cycling workstations. Cycling workstations either replace the office chair or are included as a separate component that can be used with the current chair. These provide the possibility for a non-weight bearing activity to increase the physical activity of desk-based workers and in one study, authors reported that although performance while cycling was slightly compromised, it was still found to be better than that when treadmill walking (Elmer & Martin, 2014).

Sit-Stand Desks

Sit-stand desks are height-adjustable desks that allow the user to easily alter the height of their desk between sitting and standing. Although sit-stand desks do not provide all

of the same physical benefits as a cycle or treadmill workstation, they are considered one of the more popular methods used by employers to reduce their employees' sedentary behavior. This is because these desks are considered convenient and can easily replace the normal desk while also having the smallest impact on employee motor skills and productivity (Chambers et al., 2019).

Figure 6 presents a comparison between the different types of active furniture available to employees. Following this research, an online questionnaire was sent out to validate the which type of active furniture is most commonly provided to the employee. Based on the research, sit-stand desks are the most popular and most commonly implemented piece of active furniture installed by employers. For this reason, sit-stand desks are considered the key focus for this project.

Popularity	Space Requirement	Effect on Productivity	Health Effects	Overview
If purchased, often a company purchases a few for entire company use so there is less access. In the online questionnaire, only **5%** of participants had access to a treadmill workstation.	The treadmill workstation typically takes a good amount of space and is added as an additional element to the standard office desk, rather than a replacement. Often companies incorporate treadmill desks in a separated area for	It takes a lot of practice to work and walk at the same time and treadmill work stations were found to have the greatest influence on workplace performance / productivity.	The treadmill workstation allows users to expend a little more energy when standing, especially if it is used for slow walking. Plus it is easier on the back. Walking for long periods can aggravate existing back and joint pain particularly for employees who are overweight.	Although treadmill and cycle workstations are two great options to increase physical activity within the workplace, they are less likely to be found in the office than the sit-stand desks. In addition, they do help to decrease sedentary behavior but are more-so aimed to promote physical activity as employees may not have access to them throughout the entire day but rather for a brief period.
Cycling workstations require more effort than sit-stand desks and are slightly less popular. In the online questionnaire, only **5%** of participants had access to a cycle workstation.	Cycling workstations can either be installed in place of a regular desk chair or as an addition to the chair.	It may be harder to concentrate when using a cycling desks as people's balance may be thrown off. But cycling desks were found to influence workplace performance less than that of treadmill desks.	Staying seated while being active takes pressure off of the hips and knee joints while also allowing you to be active. The desk may affect balance,	
Sit-Stand desks have been around for a long time and are now considered a necessary employee benefit. In the online questionnaire, only **61%** of participants had access to a workstation	The sit-stand desk can either be installed in place of a regular desk or as additional element attached to the desk.	Standing at a sit-stand desk was found to have the **least significant effect** on working performance. Out of 21 studies, only 8% found significant differences between sitting or standing or a combination of sitting and standing.	When you stand you burn 20% to 25% more energy than when you sit, but prolonged standing can have poor health effects. The transition in posture between sitting and standing results in the greatest energy expenditure and effect on the body.	Sit-stand desks seem to be the most common way employers are attempting to promote physical wellbeing and decrease the sedentary behavior of their employees. Therefor these desks are a great product to focus on as they are prevalent in the workplace.

Figure 6: Evaluating the Active Furniture. Sources: (Should you use an active workstation at home?, 2019); (Chambers et al., 2019); (Elmer & Martin, 2014)

CONCLUSION: THE WORKPLACE

Although the workspace is changing and a greater emphasis is being placed on the wellbeing of employees both in and out of their workplace, global sedentary behavior is continuing to increase. With the remaining presence of the Covid-19 pandemic and expectations that working from home will continue to remain popular once the pandemic is over, transportation time is now replaced with more time spent working and in turn, even more time spent in sedentary behavior both during the workday and during periods of leisure time.

To account for this, companies are investing in the physical wellbeing of their employees and attempting to limit their employees' sedentary behavior by providing solutions such as wellness programs and gym access, active furniture, and height-adjustable sit-stand desks. Based on the literature analysis, the following conclusions were formed:

The future workplace will consist of an open-office workspace designed for flexibility and promoting communication, community, and culture. The start-up scene is becoming more popular and with this, so are their typical open office and flexible spaces. Larger corporations are now adopting this trend, transitioning away from the cubicle style workplace. As the hybrid workplace model becomes more popular, the on-site office space will become a location for teams to collaborate and communication and will focus on providing the sense of belonging working adults are looking for.

Companies will invest in sit-stand desks over other types of active-furniture as these desks are easily implemented, only take up the same space as a regular desks, and have the smallest effect on productivity.

Boundaries

Through analysis, several boundary conditions are established:

1. The solution shall be designed for a flexible & Hybrid open-office/home office layout. [updated]
2. The project will focus on the promoting utilization of sit-stand desks in the workplace.

04

SIT-STAND DESKS

As mentioned earlier in the report, sit-stand desks are desks that allow the user to alternate between sitting and standing. The height of the desks can generally be altered through the use of a manual crank or electric motor. By being able to alter between the sitting or standing position, the user can better vary their body position while also reducing the time spent in prolonged sedentary behavior.

Contents

A BRIEF HISTORY

Sit-Stand desks are not new and reports regarding the negative effects of sitting all day have been around since before the 19th century.

One of the first occurrences noted of the use of standing desks traces back to the 1400s as Leonardo da Vinci was observed using the desk to design early prototypes and paint the Mona Lisa. These desks then gained popularity in the 18th and 19th centuries as owning a sit-stand desk in a person's home or office was seen as a status symbol. In the late 1700s English Presbyterian minister, Job Orton, made one of the first reported statements about the negative effects of sedentary behavior stating (Knighton, 2020):

"A sedentary life may be injurious. It must therefore be your resolute care to keep your body as upright as possible when you read and write; never stoop your head nor bend your breast. To prevent this, you should get a standing desk."

But as the world became more industrialized and machines began to replace many jobs, the employee role in the workplace transitioned and it became more common for workers to sit all day. Around the same time, a self-help book was published suggesting that professionals practice penmanship on their feet since nearly half of all business writing was done at standing desks. Inventors of the time filed patents for desks that could be raised and lowered with hand cranks (Knighton, 2020).

In the 20th century, concerns for workplace wellness began to make strides and there was a perceived shift in financial responsibility for health care, from governor to employer, as workplace wellness was linked to the occupational safety and health movement (OSH). This was promoted by the general cultural shift toward promoting fitness, emerging research findings that showed the cost of employee's unhealthy habits, and newly formed workplace health promotion groups (DeJoy & Southern, 1993). Then in 1990, the US federal government launched an initiative called Healthy People 2000 that proposed 75% of employers with 50 or more workers should offer health promotion services as a benefit (Reardon, 1998). This was followed by the first published Surgeon General's report on physical activity and health in 1996 (Sitting Disease – Standup Kids, n.d.). This article illuminated a broad body of evidence linking sedentary behavior to a wide range of negative health outcomes.

Even though reports of the negative health effects of prolonged sitting have been around for the while, the medical rationale for the standing desks only took a hit in the 2010s, with the Society for Human Resource Management stating that the number of companies providing standing desks for employees had increased by 33% (Geipel, 2018). This number was only expected to increase into the 2020s as various countries are now requiring companies to provide the opportunity for employees with sedentary jobs access to sit-stand workstations. These laws are already in place in several European and Scandinavian countries (Bird, 2015). So although in the past the desks were catered to the more wealthy, today adjustable desks are available to anyone and are becoming increasingly popular as people are caring more about their health and are learning about the health risks of sitting for long periods.

Job Orton states that "a sedentary life may be injurious."

Leonardo da Vinci used a standing desk while designing early prototypes for modern inventions and while he painted the Mona Lisa.

Inventors of the time filed patents for desks that could be raised and lowered with hand cranks.

Standing desks are considered a status symbol and used increasingly among the rich in their homes

1860s

1800s

By the end of the Industrial Revolution and the effects of new technologies had transformed the workforce in the USA, with workers finding themselves seated and

Employers were often not given their own desks, but shared communical desks, which were often built at standing height.

Thomas Jefferson ordered a "tall desk" with 6 peg legs from a Williamsburg cabinet maker.

1968

1900s

Perceived shift in financial responsibility for health care, from governor to employer

Companies begin to offer workplace wellbeing programs

Propst and Herman Miller released the "Action Office 1" a system featuring adjustable

Federal government launched an initiative called Healthy People 2000

2015

2010s

1996

The number of companies providing standing desks increased by 33%.

The first published Surgeon General's report on physical activity and health that illuminated on the negative effects of prolonged sitting.

Denmark passed a law making 'sit-stand' desks a legal requirement

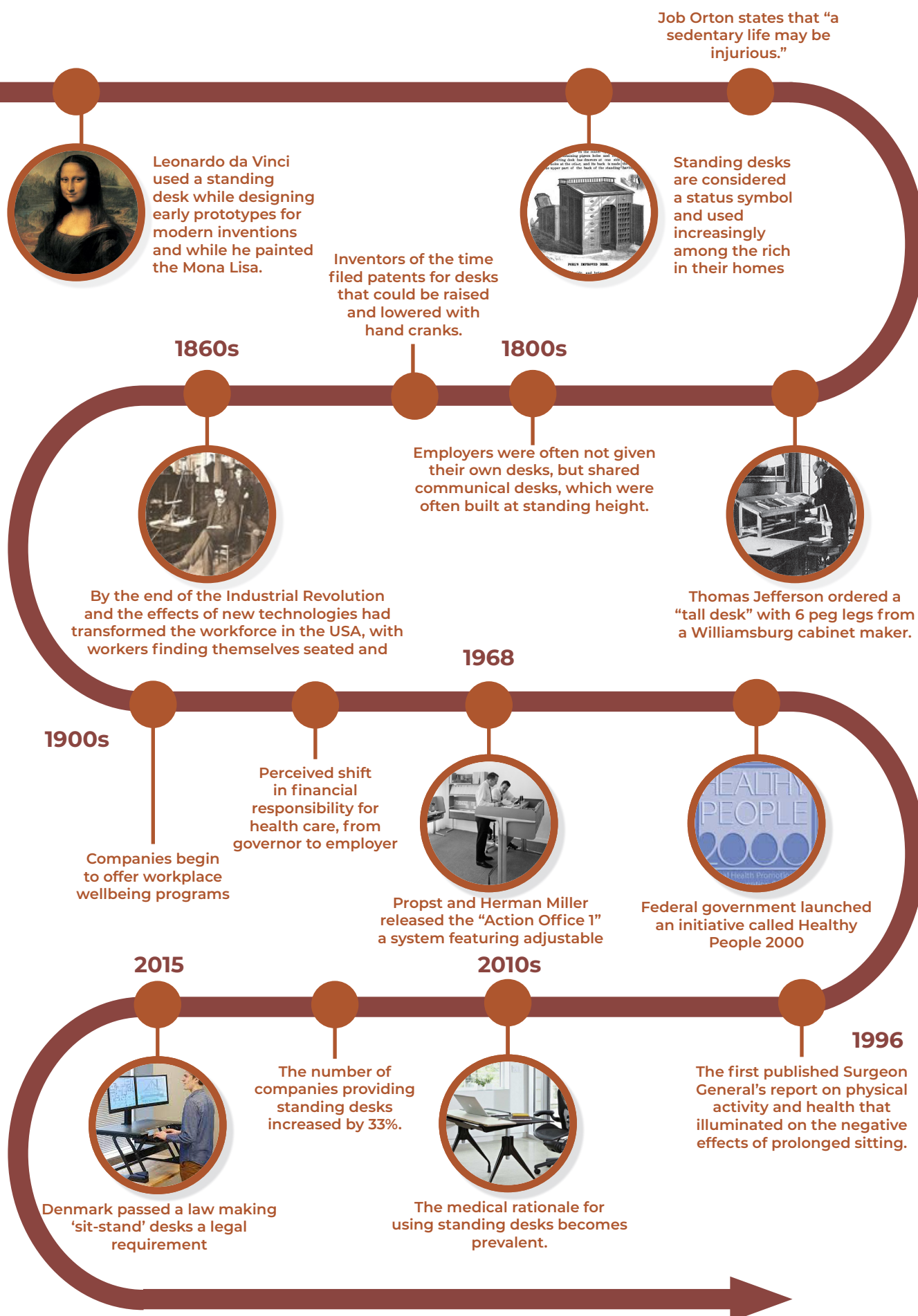The medical rationale for using standing desks becomes prevalent.

Figure 7: The history of Sit-stand Desks. Sources: (Knighton, 2020); (DeJoy & Southern, 1993) (Reardon, 1998); (Sitting Disease – Standup Kids, n.d.); (Geipel, 2018); (Bird, 2015)

SIT-STAND DESK ERGONOMICS

The design of the sit-stand desk is aimed at allowing the user to avoid static sitting as well as static standing by providing them with an easy means to vary their body position more often. To obtain the most beneficial outcome from using the desk, it is important to understand the proper ergonomic set-up for when the user is both standing and sitting.

The Desk Set-Up

There is not one specific body position that is recommended for sitting. Every worker can sit comfortably as long as they adjust the angles of their hips, knees, ankles, and elbows. The general recommendation for proper workplace ergonomics and good desk posture is to maintain a neutral position when both sitting or standing. In this neutral position, the natural S-curve of the back is maintained so that the cervical curve (neck), thoracic curve (area between the neck and the abs), the lumbar curve (connects the abs to the lower body) have a balanced alignment. By maintaining this natural S-curve, the bones are properly aligned reducing stain on an individuals muscles, joints, and ligaments (Russell Brown, 2016).

Figure 8 presents the suggested neutral posture while using a sit-stand desk.

Static Standing

The most beneficial aspect of the sit-stand desks is the ability to transition between the different positions as both static sitting and static standing can cause muscle fatigue and discomfort, hinder blood circulation, in addition to other health effects.

To explain this further, sitting specifically is not resulting in all-cause mortality, it is the static and prolonged nature of sitting which has resulted in sedentary behavior and the adverse health effects that come with it. These effects come into play as well when an individual takes part in static and prolonged standing. The human body was designed to move and placing it in an unnatural position that restricts movement, can lead to a decrease in the circulation of blood (Madeleine et. al., 1998). This results in deterioration such as loss of bone density, stiffening of joints, weakening of muscles, heart and lungs, and degeneration of the cellular energy systems (Gummelt, 2015). Many studies have been done to observe the outcomes of static standing. These studies consistently presented increased reports of low back pain, physical fatigue, muscle pain, leg swelling, tiredness, and body part discomfort due to prolonged standing (Waters & Dick, 2015).

Therefore, interventions designed to reduce the risk of adverse health outcomes due to prolonged static sitting and standing can be effective. It is important to focus on designing a solution that encourages working adults to modify their posture so that they mix sitting, standing, and general alteration of their static posture.

When in sitting or standing position, be sure that:
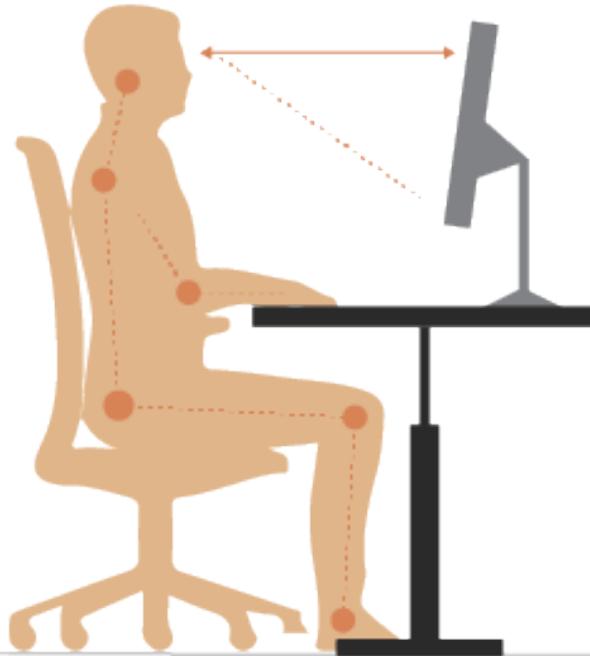
✓ Hands, wrists, and forearms are straight, in-line and roughly parallel to the floor.

✓ Head is level or bent slightly forward, forward facing, and balanced.

✓ Erect or upright spine.

✓ Shoulders are relaxed and upper arms hang normally at the side of the body.

✓ Elbows stay close to the body and are bent between 90 and 120 degrees.

✓ No twisting of the upper torso.

✓ The in-line sight is between the horizontal and 35 degrees below the horizontal

When in standing position, be sure that:

✓ The platform height is approximately at your standing elbow position

✓ The keyboard and mouse are aligned as you would when you are sitting.

✓ The height of the monitor should still be between horizontal and 35 degrees below.

✓ The head, neck, toso, and legs should be in line.
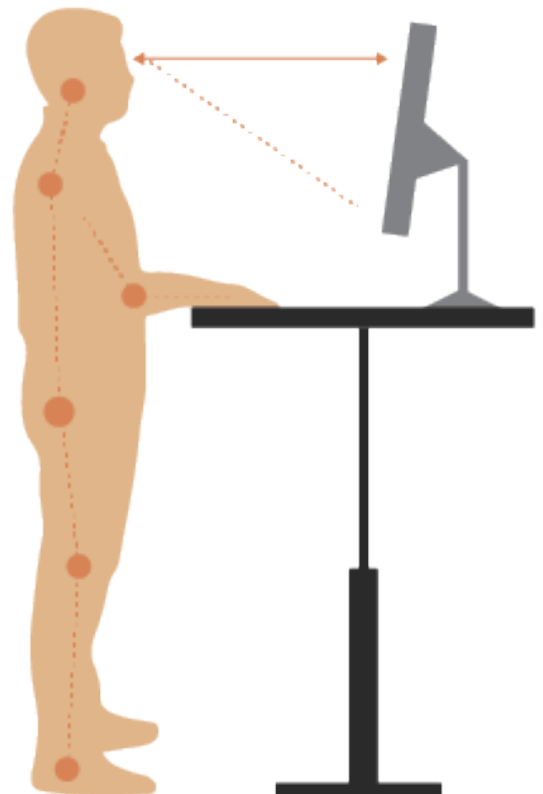
Figure 8: Ergonomics of Sitting and Standing. Sources: Canadian Center for Occupational Health and Safety .

Reduction in Back Pain and Musculoskeletal Discomfort

Lower Risk of Cardiovascular Diseases

Lower Risk of Weight Gain and Circumference

Lower Blood Sugar Levels and Risk of Type 2 Diabetes

Improved Mood, Productivity, and Energy Gain

Increased Social Engagement

Figure 9: The Benefits of using a Sit-stand desks to change positions.

THE BENEFITS OF SIT-STAND DESKS

As more reports and studies come out about the negative health effects of sedentary behavior, people are becoming more health-conscious and are taking action towards reducing their prolonged periods of sitting. Through the implementation of sit-stand desks in the workplaces, studies have indicated there is a modest but significant decrease in sedentary time (Straker et al., 2013). Using these desks, and altering between the standing and sitting position, has an array of physical and psychological health as well as social benefits.

Reduces Musculokeletal Discomfort

As mentioned in the previous sections, the human body is meant to move and by placing it in a static standing or sitting position for a prolonged period, there is a decrease in the circulation of blood which reduces the nutrient supply to muscles, resulting in muscular fatigue. This may result in WMSDs (work-related musculoskeletal disorders) (Halim & Omar, 2011). This is experienced somewhat differently when in the two positions. Prolonged static sitting influences the intervertebral spacing within the spine and places pressure on the intervertebral discs (Kroemer & Grandjean, 1997). In addition, sitting increases ligament strains and may place high loads on various muscles and tendons, increasing the risk of pain, discomfort, strain, and injuries (Zemp et. al., 2016). Prolonged periods of static standing may also result in discomfort and fatigue particularly in the lower limb muscles, lower back, and feet. When following an unfavorable working posture, there is also a potential increase in the muscle tensions of the neck and shoulders as they are "overstained" This is due to an increase of the pressure on the blood vessels resulting in the blood vessels towards the arm becoming partially pinched(Halim & Omar, 2011. & Laurent, n.d.).

By altering between the sitting and standing position, and reducing this static nature, there can be a reduction in these pains and muscular discomfort. A study done by the "Take-a-Stand Project" in 2011 found that participants who spent an average of 66 minutes of their workday standing, experienced a 54% reduction in the upper back and neck pain (Pronk et al., 2012). Similar results were found in various additional studies which found that standing for part of the day helped to alleviate lower back pains and that although participants experience short term discomfort from altering to a standing position, the discomfort was resolved after a few weeks (Dutta et al., 2015; Chambers et al., 2019b).

Lower Risk for Cardiovascular Disease

The sedentary lifestyle has been linked to an increase in the risk of cardiovascular events. This is because when the body is static for too long, it stops using blood sugar and leads to a decrease in metabolism, blood flow, and muscle activity. By integrating periods of standing between periods of sitting, it is possible to evoke a higher rate and activity of the muscle in the leg (Altenburg et al., 2019). It is important to note that standing interruptions may not be an adequate solution to combat potential

acute negative cardiometabolic effects of prolonged sitting. It is recommended that to improve cardiometabolic health, prolonged periods of sitting should be interrupted with regular moderate-to-vigorous physical activity (Altenburg et al., 2019).

Lower Waist Circumference and Risk of Weight Gain

Research indicates that standing burns 0.15 kcal per minute more than sitting and this gap in energy expenditure could be even greater as participants were standing still in the study, but often when people stand they tend to move around more and make spontaneous movements (European Society of Cardiology, 2018). Although some studies indicate that the use of sit-stand desks can lead to greater energy expenditure and, in turn, weight loss or reduction in weight gain, there is not enough significant evidence for this as studies tend to contradict each other. .

Lower Blood Sugar Levels and Risk of Type 2 Diabetes

Prolonged sitting inhibits the metabolizing of fat and sugar from the bloodstream, thus increasing the risk of type 2 diabetes and cardiovascular diseases. By breaking up these periods of sitting with transitions to standing or other low-intensity activities postprandial glucose levels and insulin sensitivity are beneficially influenced. A study done by Dunstand et al. (2012), found that by briefly breaking up prolonged periods of sitting with light-intensity activity, there was a 24-30% decrease in the glucose levels and a 23% decrease in insulin levels. This is important because blood sugar levels should be kept in a specified target range to help prevent or delay long-term, serious health problems such as heart disease, vision loss, and kidney disease. Staying within a pre-set target range can also help to improve energy and mood (CDC, 2019).

Improved Mood, Productivity and Energy Levels

As stated in one of the previous sections, when using a sit-stand desk in the standing position, the user is more likely to make spontaneous movements by shifting their weight to become more comfortable and feeling freer to walk around. This movement, in addition to the transition period when one alters their position, allows for an increase in the delivery of oxygen and nutrients to the body through improved blood flow. This increase in movement is linked to improved concentration, an increase in energy levels and productivity levels, lower stress, and improved mood (Garrett et al., 2019; New Balance Associates & Wellness & Prevention, 2012; Jensen, 2005). Several studies also indicated that out of 21 studies that analyzed the difference in productivity between sitting and standing, only 8% reported significant differences. Four of the studies that found significant differences indicating that productivity during standing was superior to that which occurred while sitting (Chambers et al., 2019).

Increased Social Engagement

In a study conducted by Dutta et al. (2015) about the experience of switching from a traditional sitting workstation to a sit-stand workstation, results indicated that the use of sit-stand workstations increased workplace interactions without being disruptive. In the study, participants noticed that the increased visibility of colleagues led them to feel more comfortable about approaching them with questions, that they would have previously emailed, and they were more likely to have impromptu conversations about work-related issues. Also, by being able to view their colleagues, participants suggested that they were provided with cognitive cues to interact with others on work-related matters (Dutta et al., 2015).

SO WHAT IS THE PROBLEM?

Lack of Utilization

In a study done by Wilk et al. (2006) involving four Swedish companies which had purchased both electric and manual sit-stand desks for their entire departments, results indicated that 60% of men and women, across four companies, who had recently been provided with sit-stand desks, reported using them once a month or less. The primary reason for not adjusting the desk, cited by two-thirds of those studies, was that the individual 'could not be bothered,' with another third reporting that they already had sufficient variation in posture (Wilks et al., 2006; Staker et al., 2013). Often participants who were motivated to use the desks before the experiment, with a recurring reason of health, were the ones who more commonly continued to use the desks long-term (Grunseit et. al., 2013). But even among these participants, studies show that despite their initial enthusiasm, employees often forget or lack the continuous motivation to switch to the standing position, and they end up sitting more than they initially intended.

Literature Analysis

To develop a base understanding for why this lack of utilization occurs, a literature analysis was done on existing research studies focused on the use of sit-stand desks in the office. This analysis provided insights into the personal, social/cultural, and environmental factors that influence whether or not a participant used the desk in both the sitting and standing positions.

A list of the different studies analyzed is presented in the table below.

Results from the different studies were written down and clustered into different categories based on similarities. Once the categories were formed, they were divided into two larger groups based on whether they were facilitators for using the sit-stand desks or barriers. A summary of these clusters is presented in Figure 10 on the following page and further described in the following sections. References for the data is shown in the table below.

Studies included in Sit/Stand Desk Review

Authors	Article Title	Year Published
A.C. Grunseit, J. Yuk-Yin Chau, H.P. van der Ploeg, & A. Bauman	"Thinking on your feet": A qualitative evaluation of sit-stand desks in an Australian workplace	2013
L. Straker, R.A. Abbott, M. Heiden, S.E. Mathiassen, & A.Toomingas	Sit–stand desks in call centres: Associations of use and ergonomics awareness with sedentary behavior	2012
A.j. Chambers, M.M. Robertson, & N.A. Baker	The effect of sit-stand desks on office worker behavioral and health outcomes: A scoping review	2019
N. Dutta, T. Walton, & M.A. Pereira	Experience of switching from a traditional sitting workstation to a sit-stand workstation in sedentary office workers	2015
S. Wilks, M. Mortimer, & P. Nylen	The introduction of sit-stand worktables; aspects of attitudes, compliance and satisfaction	2005

Facilitators

Relief of Physical Discomfort

Active Workplace Culture

Coworker Support/Influence

Hierarchal Support/Influence

Increased Productivity

Purpose in Movement

Pre-Existing Motivation

Social Engagement

Instructions

Facilitators

· ·

Barriers

Physical Discomfort

Static Workplace Culture

Lack of Motivation

Social Disapproval

Fear of Decreased Productivity

Lack of Awareness

Lack of Awareness (PA)

Desk Design

Psychological Discomfort

Figure 10: The Facilitators and Barriers. Pages Sources: Grunseit et. al., 2013); (Straker et al., 2013); (Chambers et al., 2019c); (Dutta et al., 2015); (Wilks et. al., 2006)

The Facilitators & Barriers to Sit-Stand Desk Use

Physical (Dis) Comfort

Although one of the benefits of altering to the standing position is the reduction in musculoskeletal discomfort, there were mixed feelings regarding how participants experienced (dis)comfort when in the standing position.

+ Participants felt immediate relief to musculokeletal pains when adjusting positions.
− Many participants took on all-or-nothing mentality
− Prolonged static standing can also lead to physical pains
− Without practice, the muscles become fatigued

Static vs. Active Workplace

The influence of company culture was significant in determining whether participants felt at ease and able to alter their working position. For this report the static and active workplace culture is defined as follows:

Active Company Culture occurs when the use of the sit-stand desk is normalized and many employees have taken up the practice. There is more movement around the office and less pressure to remain seated. Active work environments present the following facilitators:

+ Standing is normalized in workplace culture
+ Less feeling of pressure to remain seated

Static Company Culture occurs in an office where the majority of employees remained seated throughout the workday and there is a lack of movement around the office. In this culture, the employee is seen as being more productive as long as they remain at their desk. In the case of the static environment the following barriers were found:

− All workplace environments are

designed for sitting
- Sitting is the nature of the job
- Sitting is a subconscious habit
- There is perceived pressure to stay seated

Social Support vs Social Disapproval

Social support or disapproval stems from coworker and supervisor (dis)use of the sit-stand desks and whether they promote the behavior or disapprove of it. As individual behavior is influenced by social norms & interpersonal relationships, this factor had a large influence over whether the participant was willing to use the sit-stand desks.

- Employees who saw their coworkers using the sit-stand desks influenced them to use it as well
- Going through it with your peers (support with understanding)
- Top-down influence, seeing supervisors do it influenced them
- Worry of disapproval from supervisors or coworkers
- Worry of being seen as less productive
- Standing felt like an appropriate of power

Motivation

Motivation played a major role in whether participants were successful in altering their sedentary behavior and using the sit-stand desks. For participants who were able to keep up long-term utilization of the desks, there was often pre-existing motivation mainly related to health reasons. But for many participants this motivation needed to come from somewhere else.

- Previous desire to use
- Use as an intervention for health related issues
- Autonomous motivation (their own decision to adjust their behavior)
- A majority of participants "could just not be bothered"
- Optimism bias that negative health effects will not impact them
- Sitting is a subconscious habit

Productivity

Research showed that altering from the sitting to standing position often led to an increase in energy, mental alertness, and increased or negligible effect on productivity (Garrett et. al., 2019; Chambers et. al., 2019). Participants who were able to develop long-term sit-stand practices reported these outcomes, but many participants found that they often forget to change, or decided not to change to standing, because of fears that this would not be the case.

- Many participants found that standing led to a boost in productivity and mental alertness
- Participants felt that their energy levels increased
- Environmental Pressures (e.g. deadlines, meetings, surveillance)
- Fear that standing will lead to a decrease in productivity and focus

Awareness

The studies showed that awareness of the adverse effects of sedentary behavior and how to best utilize the desk had an influence on whether or not participants use the sit-stand desks. Many were unaware of the effects of sedentary behavior and believe that the physical activity they did outside of the office would compensate for their prolonged static sitting. In addition, some participants had an all-or-nothing mentality, believing that if they stood, they had to stand for the entire workday to reap the benefits.

- Those who received instructions were more frequent users
- Companies who make investment in education and motivation are often more successful
- Individuals who do not feel pains from sedentary behavior, do not always see it as a negative behavior
- "It wont happen to me" mentality
- Many people are unaware of the health risks
- Employees have a preferred time for physical activity (PA)
- Employees may believed if they reach the guidelines on PA, than it counteracts sedentary behavior

Physiological Discomfort

Connected to an environment where sitting is the norm and there is an overall static nature, a psychological discomfort was associated with standing, particularly when the participant was the only one standing.

- Discomfort at being seen more than others
- Standing felt like an appropriation of power
- Worry of distracting others

Literature Limitations

Many of the studies already done focused on individuals who could be group into the category of "early adopters." These included individuals who had already purchased the desks for health reasons or who had been interested in using them before the start of the study.

Since more and more companies are implementing the sit-stand workstations in their offices, it is important to not only analyses the "early adopters" who had self-promoted reasons for initially purchasing the desks but to also analyses users who received the desks from their companies and chose to either take advantage of the desk's standing feature or not.

CONCLUSION: EXPECTED SIT-STAND BARRIERS

Sit-stand desks have been around for a long time, but only in the last decades has there been the realization that sedentary behavior, particularly in the workplace, needs to change. To promote this outcome, many companies have purchased height-adjustable sit-stand desks for their employees. But even with these good intentions, studies suggest that working adults continue to remain seated for prolonged periods and end up using the sit-stand desks less often than they initially intended.

Through a literature analysis of the current studies which analyze why this lack of utilization occurs, an overview of the expected facilitators and barriers to sit-stand desk use was created and the following conclusions were formed:

A static workplace culture results in static workplace behavior. As individual behavior is often influenced by the social norms of their surroundings, the environment where they work often influences their behavior. In this case, working in a static environment where pressure is high and sitting is related to an individual's productivity levels, static sitting remains the norm, and going against this norm generally makes an individual stick out.

In an environment where a majority of employees do not utilize the sit-stand desks, there is an increased psychological discomfort when attempting to use them. Several factors may contribute to this. The first is that often the sit-stand desks create noise when their height is adjusted, so when an individual attempts to alter the desk height, they create noise and may worry that they are distracting their coworkers. The second is that once the working adult is standing, they become more visible than those around them, which may result in distracting coworkers or an additional feeling of discomfort at being seen more, particularly if they are the only ones standing in an open office environment.

People are unaware of how to best use the sit-stand desks and may develop an all-or-nothing mentality. Like smoking or starting to exercise, there needs to be a gradual adoption of the standing habit. Often users who want to start to use the sit-stand desks take on an all-or-nothing mentality where they think that they need to stand for a majority of the day to get the most beneficial outcome. But as the user's body is unaccustomed, or trained, for this practice, it may result in fatigue and discomfort. In addition, the user then often stands statically for a long period which is also unhealthy.

Sitting is a subconscious habit and there is a general lack of motivation to alter this behavior. All of the environments around us are designed for sitting, and therefore over time sitting has become a habit. Changing a habit is difficult and when that habit is considered to be the norm in an environment, there tends to be a general lack of motivation or desire to alter the habit. This is present in the literature analysis as many participants could just not be bothered to alter their desks to the standing position.

People are unaware of the physical and psychological benefits that correlate to altering the height of the desk and their posture throughout the day. As work generally requires working adults to be productive to get work done and make deadlines, many participants in the study remained seated as they believed they would be less productive working in a standing position. It is interesting to compare this to employees who were able to form the habit, as these employees found standing led to an increase in productivity, mood, and energy levels. This also applies to physical discomfort. Participants who were able to adopt the sit-stand habit also experienced a reduction in the physical discomfort that occurs when static sitting or standing.

Requirement

As mentioned in this section, sitting is not particularly the key problem, it is the prolonged periods of remaining in a static position that results in the adverse health outcomes many working adults face. This static nature is unhealthy and it is the transitions between sitting and standing which are the most important to emphasize when designing a product. For this case, the following requirement was created:

1. The product should promote the transition between sitting and standing, not just standing alone.

05
THE WORKING ADULT

Contents

THE TARGET GROUP

Working-age adults, particularly those who are desk-based workers, are considered a high-risk group for the adverse effects of sedentary behavior. This is because these individuals spend about a third of their lives in the office and a majority of that time sitting behind their desks.

This project will specifically focus on desk-based working adults who have access to sit-stand desks but fail to alter between working in the sitting and standing positions. These individuals typically work 6+ hours and spend at least 70% of their workday sedentary. They may want to use their standing desks more often but need extra support or tools to help them with this.

Although the final solution should be usable by all working adults, a special focus will be placed on young professionals . This is done for two reasons. First, one boundary set for the project is to design for prevention rather than for intervention. As these individuals are newer to the workforce, they may just be starting to experience the adverse effects of the sedentary lifestyle and the pains that occur from it. By designing for prevention, the goal is to limit their exposure to the adverse effects, rather than fix what has

already occurred. Second, there is easy and convenient access to this group.

The following sections present an overview of the target group and user research used to verify the conclusions created through the literature analysis. The research will be used to create personas of the target group and provide an understanding of the user's values and needs.

ALTERING THE SITTING BEHAVIOR

By designing a solution that will promote working-age adults to use their sit-stand desks in both the sitting and standing position, the aim is to motivate users towards forming a new habit that will inevitably alter their workday behavior. Before diving into the factors that influence an employee's utilization of the sit-stand desks, it is important to understand what drives humans, specifically the employee, and what they may need to change in their behavior.

Behavior Change

Altering the sedentary habits of working adults will result in a change in their daily behavior and to best understand how behavior change works, it is important to look into how behavior change works. One of the most known approaches to change is The Transtheoretical Model of Behavior Change developed by Prochaska and DiClemente in the late 1970s. The model focuses on the decision-make of the individual and is a model of intentional change that states that people do not change behaviors quickly and decisively but through a series of six stages presented in Figure 9 (Cherry, 2020; LaMorte, 2019). In this model, people often start unwilling or resistant to change but eventually develop a proactive and committed approach to altering their behavior from around a gradual progression of small steps (Cherry, 2020).

Habit Formation

In line with behavior change, is the need to change the habit of sitting to form the new habit of making the transition between sitting and standing. Habits are generally learned from receiving a reward and are typically triggered by situational cues. The Hook Model is a behavioral design framework created by the consumer psychology expert, Nir Etal that aims to connect the user's problem with the designer's solution frequently enough to form a habit (Batterbee, 2020). In this model there are four critical phases of the Hook Model, each designed to answer five fundamental questions:

Trigger: Things that users sense in their world which they can learn to associate with an action. *What do users really want? What pain is the product relieving?*

01 step	02 step	03 step	04 step	05 step
Pre-contemplation *No consideration of change*	**Contemplation** *Awareness of the need to change*	**Preparation** *Planning to make a change*	**Action** *Making the change*	**Maintenance** *Sustaining the change*
Strategies — Rethink behavior — Analyze self and actions — Asses behavior risk	**Strategies** — Weigh pros and cons — Confirm readiness — Identify barriers	**Strategies** — Write down goals — Prepare plan of action — Make list of motivations	**Strategies** — Reward successes — Seek out social support	**Strategies** — Develop coping strategies — Remember to reward self

Figure 10: The 6 stages of behavior change. Source: (Cherry, 2020)

Action: The key behavior that users want to perform. *What is the simplest action users take in anticipation of a reward, and how can the product be simplified to make this action easier?*

Variable Reward: an unpredictable positive consequence of the user's performed action. *Are users fulfilled by the reward yet left wanting more?*

Investment: Time, effort, and personal information users contribute to the product to improve the overall experience and create more value in it. *What bit of work do users invest in the product? Does it load the next trigger and store value to improve the product with use?*

When users go through all four phases of the Hook Model, they will begin to associate the product as the source of relief, and that is when the habit is formed (Batterbee, 2020).

Human Motivation

Human motivation plays a critical role in taking the first step towards developing a new behavior or habit and maintaining it. The Self-Determination Theory (SDT) is a comprehensive framework outlined by Ryan and Deci (2000) which states that people's inherent growth tendencies and innate psychological needs are the basis for their self-motivation and personality integration. The Theory focuses on how personal, social/cultural, and environmental factors can facilitate (or undermine) a person's sense of willingness and initiative and how these factors can support people in fulfilling their three basic needs:

Autonomy: people have a need to feel that they are the masters of their own destiny and that they have at least some control over their lives/behaviors. They need to feel that their decision to adjust their behavior and use the sit-stand desk as it is intended for, is in fact their own decision.

Competence: people have a need to build their competence and develop mastery over tasks that are important to them.

Figure 11: The four critical phases of the Hook Model. Source: (Batterbee, 2020)

Relatedness: people need to have a sense of belonging and connectedness with others. This is important as the primary reason people initially alter their behavior is because the behavior is promoted, modeled, or valued by significant others with whom they feel (or want to feel) attached or related.

A product or service that is able to fulfill all three of these basic needs is more likely to be successful as it will in turn promote an individual's wellbeing and provide them with the tools they need for self-motivation.

All individuals are motivated differently and individual differences in personality often result from varying degree to which their three basic need have been satisfied. Appendix III outlines the various types of motivation and there regulatory styles. By designing to support autonomous motivation, eg. motivation that comes from internal sources, there is a greater potential for an individual to actively transform values into their own resulting in a greater sense of success and satisfaction.

Existing Products Overview

To gain a better overview of how behavior change and habit formation can be promoted using products, an analysis was done looking into existing products on the market that are meant to help users quit smoking, stop biting their nails, or form exercise habits. These three behaviors were selected as smoking and nail biting are two known habits that are relatively difficult to change and exercise is a behavior that can be difficult to form.

Method

An online search was used to find products that aid users in altering their existing behaviors or habits. This search provided insights into what elements of these products seem to work.

Results

A summary of the results of this search are presented in Figure 12. Some of the key elements that appeared to repeat in these existing products and stood out as potential elements for the final solution included the following:

- Healthy rewards
- Setting up plans in the morning
- Easy tracking
- Scheduling / notifications
- Progress Overview
- Tips and Tricks
- Group Intervention
- Social Support
- Identifying Triggers
- Gradual Change
- Habit Replacement
- Reminders

Figure 12: Motivational and habit formation/alteration production the market.

The Habits to Alter

Digital Products

Physical Products

What seems to work?

Exercising

MyFitnessPal
Fitbit
Strava
Ring Fit Adventure
MapMyFitness
Nike Training Club
RunKeeping
Samsung Health
Fiton
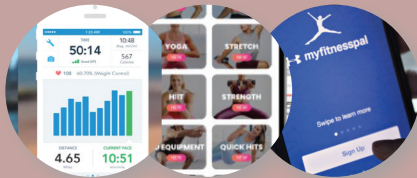
Personal Trainer
Fitbit Charge / Apple Watch
Exercise Cards
At home workout Mirror
Pebble (fitness Trackers)

Healthy rewards
Setting up the plan/goal in the morning
Logging workouts
Support system
Gradual change
Easy tracking
Scheduling / Notifications
Progress Overview
Peer / Professional Support
Tips & Tricks to improve
Gameification
Geolocation & Wearable Integration

Smoking

The Quitter's Circle
SmokefreeTXT
QuitNow!
Smoke Free
Flamy
Quit Tracker
Quit Genius
Smoking Log

Nicotine Patches
Nicotine Gum
Lifesign Quittkey
Pavlok Trainer
Quitbit Lighter
Lozenges

Individual / Group Interventions
Readiness to Quit is Key
Coworker Support
Ease & Convenience
Step-by-Step Programs
Habit Replacement
Making a plan
Identifying triggers
NRP Therapy
Accept Failure
Rewards
Tracking & Progress
Control over actions
Log Cravings
Tips & Advice

Nail Biting

Raylex App
Nail Biting

Bitter tasting nail polish
Nail File
Monarch Herbs
Chewabe Necklaces
Individual Finger Gloves
Biter Friendly Nails
Habit Aware
Raylex Pen
Fidget Toys

Keep nails trimmed
Regular manicures
Identify triggers
Gradually stop
Mindfulness
Accountability
Habit Replacement
Healthy diet
Celebrate success
Distract hands
Cover nails
Tips
Progress tracking
Reminders
Limit ability

USER RESEARCH

So far, the facilitators and barriers discussed in the previous sections are based on literature analysis and existing research studies about sit-stand desk use. To verify the existence of these challenges, user research is done looking into the experience of working-age adults with their sit-stand desks. As mentioned in the previous section, one of the limitations of the existing studies was that they tended to analyze users who fall into the category of "early adopters" and who were interested in using the desks before acquiring them. The following study analyses users who fall into this category as well as users who were provided with the sit-stand desks by their company and did not have a previous interest in using them. Overall participants in the study fell into four use profiles: highly active, moderately active, low activity, and not active. By analyzing these different user profiles, insights about the different personal, social/cultural, and environmental factors users encounter that affect their sit-stand desk use can be gained.

Validation of Sit-Stand Barriers

To validate the assumptions developed from the literature study in the previous sections, and to better understand the barriers that prevent users from utilizing their sit-stand desks as intended, three different studies were done. Appendix IV presents an overview of the methods and results of each study.

Study 1: Auto-ethnographical research
Study 2: Online questionnaire
Study 3: Interviews with working adults -

Study 1: Auto-ethnographical Research

The study involved documenting my personal sit-stand transitions, observations, and feelings over the course of the day for three weeks. Insights of my experiences were recorded by hand using a basic template consisting of the day, the scenario, and the time of each written note. The note taking generally began between 08:45 and 10:15, depending when I started my workday, and typically finished around 17:00, when the workday was complete. Further details regarding the method are describe in Appendix IV.

Study 2: Online Questionnaire

Prior to the interviews, a survey was sent out to potential participants to determine whether they qualified for the research study. To qualify, participant were required to conduct desk-based work for at least 6 hours per day and have had access to a sit-stand desk for a last three months. The questionnaire also asked questions aim at gaining insights to the participants work experience and access to elements meant to promote their physical wellbeing at the workplace.

Overall, 11 of the 18 participants who filled out the survey qualified for the interviews. These individual ranged from avid sit-stand desk users (standing for at least 50% of the day) to those who rarely or never used the standing feature of the desk (standing for a maximum of 10% of the day).

Study 3: Interviews with Working Adults

Face-to-face interviews were used to better understand the working adults' experience with their sit-stand desks and to verify the conclusions created based on the literature analysis. These interviews provided new insight to user opinions, motivations, and behaviors concerning their use of sit-stand desks and what factors contribute to it.

This study was broken up into two parts. The first part looks specifically at users who have access to sit-stand desks and have low to no utilization. This part of the interviews was meant to verify the barriers that these working-adults face towards using their sit-stand desks. The second part involved working-adults who have moderate to high utilization of the sit-stand desks. This part of the interviews was meant to look that what facilitators help these users to use the desks as much as they do and which aspects can be used to help those who have low to no utilization levels.

Overall, nine assumptions about the barriers preventing users from using the sit-stand desks were formed based on the literature analysis. These assumptions are evaluated in the following sections and figures will be used to further elaborate where needed. The study number will be indicated following each of the insights.

It is important to note that the online questionnaire and the interviews were done with a relatively small sample size. Therefor the following results and terminology used (e.g. confirmed, partly confirmed, and declined) may not be representative of the entire target group.

Verifying the Assumptions

Working adults are not aware that their prolonged periods of static sitting can have a long-term negative effect on both their mental and physical health.
As mentioned in the literature analysis, even though reports of the negative health effects of prolonged sitting have been around for decades, the medical rationale for using sit-stand desks and reducing sedentary behavior only became more prevalent in the 2010s. As these reports are relatively recent, working adults may still not be aware of the long-term adverse effects that may occur due to their sedentary behavior.

- People are only partly aware of the side-effects of long-term sitting (3)
- People think it is good to alter through different postures and move at their desks (3)
- People are more focused on the "current" pains and discomforts that come from static sitting or standing. (3)
- People are aware they need to change the sedentary habit as it is not good for them but relate this to lack of physical activity (1 & 3)
- People generally just can't be bothered to alter their position (3).

Results: Partly confirmed. Many of the participants who took part in the study were aware that their prolonged periods of sitting were unhealthy for their bodies but also were unaware of how these periods of static behavior could have long-term consequences and what these consequences are.

Working adults may not be aware that these effects are not negated by taking part in brief bouts of physical activity outside of the workplace.
The literature analysis suggested that often sedentary behavior is correlated to physical inactivity and the lack of reaching the recommended goals for exercise. Individuals often believe that if they do exercise, this accounts for their sedentary behavior.

- Using the sit-stand desks as intended is seen as easier for individuals who are more active outside of the workplace. (3)

- Working in the standing position is sometimes viewed as a valid alternative to exercise. (3)
- People view the negative effects of sedentary behavior to be due to the lack of physical activity rather than being in a static posture for a long period. (1 & 3)

Results: Confirmed. This assumption was confirmed by participants who had both low and high utilization of the desks. Participants with low motivation to use the desks often believed that it would be much easier for those who were physically active and those individuals would also be more interested. Participants who used the sit-stand desks often also believed that by utilizing the desks in the standing position, they didn't need to exercise as often.

The future workplace will consist of an open-office workspace designed for flexibility and promoting communication, community, and culture.
According to the trend analysis, Covid has accelerated the digital transformation of the workplace resulting in employees being able to work anytime from anywhere. Combining this with the trend of start-ups and large corporations transitioning from the cubical office layout to the open-office layout, flexible spaces where the office is seen as a center for communication, community, and culture is expected to become a popular option in the future.

- 72% of participants stated that when they do work from the office, they work in an open office layout. (3)
- 9% of participants worked from a cubicle layout (3)
- 45% of participants were working from home full-time at the time of the interview and questionnaire (2 & 3)
- All of the participants who worked from an open office had access to their own personal desk and space to work from (3).

Results: Partly confirmed. Although the future office is expected to consist of the flexible open-office layout, many participants continue to have access to their own personal desks and desire for it to remain that way. Some participants even stated that when

the pandemic is over, they hope to be able to go into the office a majority of the week.

Companies will invest in sit-stand desks over other types of active-furniture.
Analysis of current company practices showed that implementing sit-stand desks was considered one of the most popular methods used to increase employee physical wellbeing and decrease their sedentary behavior while at the office. This assumption presented the reasoning for focusing on sit-stand desks in this project.

- 5% of participants had access to treadmill workstations at their workplace (2)
- 5% of participants had access to cycle workstations at their workplace (2)
- 61% of participants had access to sit-stand desks at their workplace. (2)

Results: Confirmed. As indicated by the Online questionnaire, more than half of the participants had access to sit-stand desks at their place of work. This did not influence whether or not they utilized these desks as they were intended for.

A static workplace culture will result in working-adults taking on a static workplace behavior.
In a workplace where sitting is the norm and the majority of employees as well as their supervisors remained seated throughout the workday, an initial review of existing studies stated that it is more likely for employees to also remain seated at their desks. This lack of use relates to a lack of movement around the office in general and employees are often seen as being more productive as long as they remain seated at their desks.

- Participants felt that there was a perceived pressure to remain seated even if this was not actually stated. (3)
- If no one else is using the sit-stand desks, it is difficult to be the first. (1 & 3)
- Participants who worked in a company with an active environment were more likely to use the sit-stand desks as intended. (1 & 3)
- If employees see their coworkers or supervisors use the sit-stand desks, there is a greater possibility they will be influenced

to do the same. (3)
— In a static company, using the sit-stand desks in the standing position was not normalized. (3)

Results: Confirmed. As shown on page 54, the culture of a company has a huge influence over whether or not an employee uses their sit-stand desk or not. In an environment where no one uses the desk, it is less likely for a coworker to pick up the habit, while in an environment that is active and use of the sit-stand desks is normalized, employees are more likely to be influenced by their coworkers and pick up the habit as well.

In an environment where a majority of employees do not utilize the sit-stand desks, there is an increased psychological discomfort when attempting to use them. Individual behavior is influenced by the social norms and interpersonal relationships they have with those around them and when a person attempts to step outside of these norms there tends to be a psychological discomfort associated with being different and receiving social disapproval.

— Participants in static environments worried about how they would feel to be the only one standing. (3)
— The idea of being seen more than others proved to be a reason to remain sitting. (3)
— Being able to see coworkers more often was associated with a sense of awkwardness. (1 & 3)
— When the desks were commonly used by coworkers, this psychological discomfort was less apparent or negligible. (1 & 3)

Results: Confirmed. Psychological discomfort proved to be a barrier faced by many of the participants who worked in static environments where their coworkers also chose to not use the desks. The feeling that they would be the only ones using it and therefore stepping away from the social normed made them feel "weird" and "awkward."

People are unaware of how to best use the sit-stand desks and may develop an all-or-nothing mentality.
According to the literature analysis and existing research studies, people often believed that to gain the optimal benefits from the sit-stand desks, than they needed to use the desks in the standing position for a majority of the rather, rather than switching between the two positions.

— Participants who rarely to never use the sit-stand desks often had a perception that they needed to stand for the entire day. (3)
— Participants who felt this way often did because their coworkers used the desks in the standing position for the majority of the day. (3)
— There was a common misunderstanding between both non-active users and active users that standing for a majority of the day was healthier. (3)
— Participants in active environments were more accustomed to adjusting the height of their desk based on their body cues. (3)

Results: Partly Confirmed. There was a mixed response from participants with an understanding on how to best utilize sit-stand desks. Some participants who fell both into the low and high activity levels had perceptions that the desks should be used in the standing position as much as possible while others understood that they need to adjust according to their body's and comfort levels.

Sitting is a subconscious habit and there is a general lack of motivation to alter this behavior.
Motivation played a major role in whether participants were successful in altering their sedentary behavior and developing the sit-stand habit. There was also an optimism bias where participants often felt that the adverse health effects would not happen to them, no matter whether they altered their behavior or not.

— Participants found sitting to be easier and something that they were already accustomed to. (3)
— Forgetting to alter to the standing position was a common barrier for both none-active and active users. (1 & 3)
— Participants who were non-active users often presented more excuses for not

taking up the sit-stand habit. (3)
- Active participants were able to develop this habit by focusing on the positive physical and psychological outcomes. (1 & 3)

Results: Partly Confirmed. Confirmed for the non-active and low active users as one of the key barriers was that they could just not be bothered to develop this habit.

People are unaware of the physical and psychological benefits that correlate to altering the height of the desk and their posture throughout the day.
As stated in the literature analysis, transitioning between sitting and standing often leads to an increase in energy and mood levels. Many study participants even stated that they felt a significant increase in productivity while standing. These benefits were often felt by individuals who were able to take-up the sit-stand habit and sustain it over a long period of time. For users who were inactive, these benefits are probably not felt and are not used as facilitators to aid in the transitioning between sitting and standing.

- Participants who were not active users of the sit-stand desk mentioned that standing every so often did feel good (3).
- Participants associated working in the standing position as a means to relieve pain (particularly back pain). (3)
- Participants mentioned that they noticed the different effects using the desk in the standing or sitting position had on their bodies. (3)
- Non-active participants often focused on the negative effects that standing had on their physical and mental state. (3)
- Participants who were active users of the desk, were able to use their body and mind and cues to alter their desks based. (3)

Results: Partly Confirmed. Participants were often aware that altering their position had an affect on their mental and physical state, but paid more focus to the negative aspects. These often felt as excuses to remain in the seated position. But even these participants often mentioned that they were aware that standing felt good and it was a practice that could be used to relieve pain.

The Influence of the Workplace Environment

In the literature analysis one of the most significant findings was that the workplace environment and whether or not using the sit-stand desks was normalized had a significant influence over employee sit-stand desk-use. To validate this assumption, the workplace environments that the participants were in was assessed to determine how these environments influenced their answers when discussing the different factors that influenced them.

Figure 13 presents the results with participants all working within the four environments:

Static Work Environment: Although a majority of coworkers due have access to the sit-stand desks, few to none use the desk in the standing position.

Midway: In this environment, about half of the participants coworkers utilize the standing feature of the sit-stand desks and they other half do not.

Active Environment: A majority of a participants coworkers and supervisors utilize the standing feature of the sit-stand desks in this environment. Standing has been normalized, the environment feels relaxed and participants can alter their desk height as they please, and there is a sense of support among colleagues.

Remote: This sections includes participants who work alone and from home. As the future will consist of a hybrid workplace model, it is important to assess the facilitators and barriers these participants face as well.

Figure 13 was created by clustering participant responses and comparing their responses to their work environments. The more participants who mentioned the factor, the longer the line.
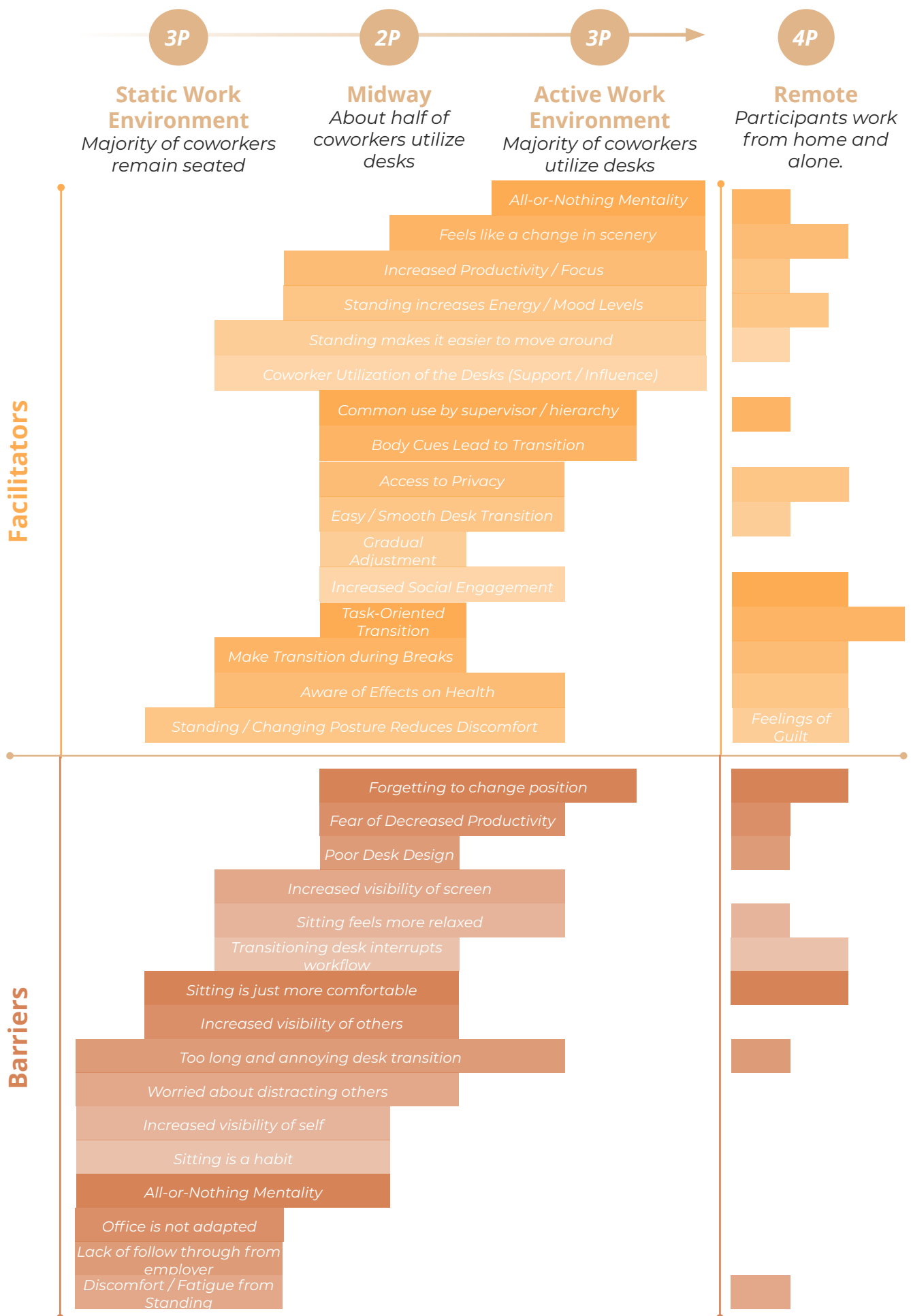
3P	2P	3P	4P
Static Work Environment *Majority of coworkers remain seated*	**Midway** *About half of coworkers utilize desks*	**Active Work Environment** *Majority of coworkers utilize desks*	**Remote** *Participants work from home and alone.*

Facilitators

- All-or-Nothing Mentality
- Feels like a change in scenery
- Increased Productivity / Focus
- Standing increases Energy / Mood Levels
- Standing makes it easier to move around
- Coworker Utilization of the Desks (Support / Influence)
- Common use by supervisor / hierarchy
- Body Cues Lead to Transition
- Access to Privacy
- Easy / Smooth Desk Transition
- Gradual Adjustment
- Increased Social Engagement
- Task-Oriented Transition
- Make Transition during Breaks
- Aware of Effects on Health
- Standing / Changing Posture Reduces Discomfort
- Feelings of Guilt

Barriers

- Forgetting to change position
- Fear of Decreased Productivity
- Poor Desk Design
- Increased visibility of screen
- Sitting feels more relaxed
- Transitioning desk interrupts workflow
- Sitting is just more comfortable
- Increased visibility of others
- Too long and annoying desk transition
- Worried about distracting others
- Increased visibility of self
- Sitting is a habit
- All-or-Nothing Mentality
- Office is not adapted
- Lack of follow through from employer
- Discomfort / Fatigue from Standing

Figure 13: Influence of workplace environment on sit-stand desk barriers and facilitators .

The Four Participant Profiles

During the interview process, it became apparent that participants fell into four different profiles characterized by their level of motivation and sit-stand desk activity. These profiles are described below and an overview of the barriers and facilitators each profile faces is presented on the following page (Figure 15).

Profile 1: High Activity

Participants falling into this profile are characterized by high levels of intrinsic and autonomous motivation and are able to transition their desks often between sitting and standing based on genuine interest and enjoyment. Often these users are self-aware and able to base the transitions on cues from their body and mind (e.g. fatigue, mood, discomfort) and do not require external reminders.

These users have fully developed the habit for the sit-stand transition and have become self-promoted sit-stand desk users. In this case, self-promoted means that these users understand the benefits of using a sit-stand desk and personally requested it from their employer (or purchase it themselves). The main facilitators that enables these users to form the habit was the reward it entails in the form of increased productivity, alertness and energy levels, enhanced mood, and a reduction in physical discomfort. In addition, these participants often had access to an active workplace environment where standing is normalized and the sit-stand desks are commonly used by coworkers/supervisors.

Profile 2: Moderate Activity

Participants falling in to this profiles are characterized by external and autonomous motivation, specifically falling into the categories of identified and integrated regulation. This means that although users engage in the sit-stand transitions and accept its value, they have not yet internalized the activity and still require external forms of motivation. These users often transition

High Activity Profile

Participants characterized by high levels of intrinsic and autonomous motivation. They are able to transition the height of their sit-stand desk based on genuine interest and enjoyment.

Moderate Activity Profile

Participants characterized by external and autonomous motivation. They transition the height of their sit-stand desk based on external motivation and influences, but are in the process of internalization.

Low Activity Profile
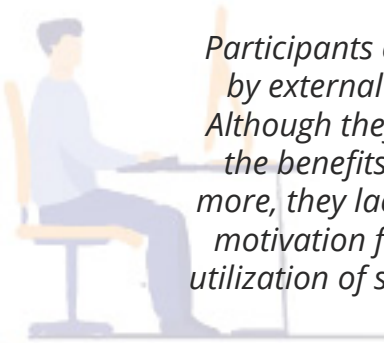
Participants characterized by external motivation. Although they understand the benefits of standing more, they lack the internal motivation for continued utilization of sit-stand desks.

No Activity Profile

Participants characterized by an amotivation profile and lack intention or are resistant to altering their sit-stand behavior.

Figure 14: The 4 Activity Profiles

between sitting and standing but these transitions tend to be influenced by their coworkers or supervisors and the users continue to need reminders or they may forget to alter their position.

Different from the High Activity profile, these users often did not have a self-promoting intention for acquiring the sit-stand desk. Rather, the desk was already existing and available for use at their workplace (company promoted), and users were positively influenced by their coworkers and/or supervisors to begin utilizing it. Although these users have not yet fully developed the sit-stand habit, they are becoming more self-aware and conscious of the positive effects these transitions physically and psychologically.

The largest barriers that Moderately Active users encounter was remembering to make the transitions, particularly when they were extremely focused on their work and slight psychological discomfort when using the desks due to increased visibility and fear of disturbing their coworkers.

Profile 3: Low Activity

Low activity participants are characterized by external motivation specifically falling into the categories of external and introjected regulation. This means that although participants in this category often understood at least some of the benefits of using sit-stand desks and had self-promoting reasons for acquiring the desks, they lack the internal motivation to actually utilize it, and when they did it is often due to guilt or pressure from external sources rather than their own values and interests. These users often had good intentions when obtain their sit-stand desks, but over time this motivation decreased and users transitioned the desks much less than they initially intended.

These users were unable to maintain the sit-stand behavior long enough to experience the benefits that it has on their physical and psychological states. This resulted in their formation of the belief that working in the standing position and transition their desk height would have a negative impact on their

focus and productivity and that to maintain these factors, they needed to remain seated. In relation to their need to remain focused, participants mentioned that they often forgot to alter their desk height, leading them to remain in the seated position even if they had other intentions.

These users often worked either from their home office or from an office that had a relatively static environment where there was a lack of use of the sit-stand desks by their co-workers and supervisors. In both cases, there is a lack of peer support and influence which is a factors that was often felt by the High Activity and Moderate Activity profiles in their workplaces.

One facilitator that many participants mentioned they believed would help them make the sit-stand transition without interrupting their work-flow would be to alter the height of their desks based on tasks and task completion. Users in the profile felt that sitting and standing had different effects (e.g. alertness, relaxation, comfort, etc.) on the mind and these effects corresponded to certain tasks they needed to compete.

Profile 4: No Activity

The No Activity profile is characterized by participants who are generally motivated and lack intention to alter their sedentary behavior. These participants believe that transitioning to the standing position is potentially ineffective and are resistant to adopting the habit. These participants were generally aware that static sitting was bad for them but lacked the knowledge of its long-term side effects, and could "just not be bothered" to make the sit-stand transition.

Users in this category have access to sit-stand desks through their employer but often focused on many barriers as to why to not use the desk (e.g. too long of a transition, too noisy transition, cables were long enough, etc.). These physical barriers were also experienced by users in the High Activity and Moderate Activity profiles but it did not affect their holistic view or use of the sit-stand desks. For these users, sitting is a habit and a norm of their workplace and making this change would

result in disrupting the environment and potentially lead to psychological discomfort from being the only one.

Summary of User Interview Results

Figure 12 on the following pages presents the results of the participant interviews. As mentioned before, participants fell into the four activity profiles (represented by each quadrant on the figure). The quadrants are separated by two-axis, level of utilization on the y-axis signifying how often the participants used the sit-stand desks to alter between sitting and standing, and self or company promoted on the x-axis. This means that either the participant uses the desk for self-promotional reasons or they only have access to it because it was provided by their company. Participants in each activity profile mentioned factors that were either barriers or facilitators towards their utilization of their sit-stand desks. In the figure, barriers are represented by brown circles, and facilitators are represented by yellow circles. As a factor was mentioned more often by participants falling into each profile, the size of its corresponding circle increases.

As shown in Figure 15, as the quadrants move from the High Activity Profile to the No Activity Profile, the number of mentioned facilitators decreases and the number of mentioned barriers increases. This makes sense as participants who are not active users of their sit-stand desks have more reasons as why they choose to remain seated.

Moderate Activity Profile

Full-time employee who has an electric adjustable sit-stand desk at her office. The desk was provided by the employer.

Intern who has both a static sit desk and a static stand desk at her office. The desk was provided by the employer.

- Feels like a change of scenery
- Access to privacy when using desk
- Coworker utilization of desks (support / influence)
- Standing makes it easier to move around
- Increased Productivity / Focus when standing
- Improves energy & mood

- Common use by supervisors
- Knowledge of need for gradual adjustment
- Increased awareness of body pains
- Reduction in Discomfort
- Easy & Smooth Transition
- Aware of effects on health
- Active Company Environment

- Increased visibility of screen
- Worried about distrubing others

- Forgetting to change position
- Increased visibility of others

Company Promoted
Desk provided by employer without user initial interest.

Full time employee who has a electric sit-stand desk at her place of work. The desk was provided by the employer.

Full time employee who has a manual sit-stand desk at his place of work. The desk was provided by the employer.

Full time employee who has a manual sit-stand desk at his place of work. The desk was provided by the employer.

- Standing makes it easier to move around
- Aware of effects on health

- Making transition during breaks
- Reduction in Discomfort
- Lack of follow-through from management
- Discomfort / fatigue from standing

- Sitting is just more comfortable
- Have all-or-nothing mentality
- Static company culture
- Increased visibility of self
- Office is not adapted to sccomodate desks
- Worried about disturbing others

- Sitting is a habit
- Increased visibility of others
- Increased visibility of screen
- Transitioning interuptswork flow
- Too long and annoying desk transition

No Activity Profile

Low or No Utilization

Figure 15: User Research Results: Facilitators and barriers experienced by the different profiles.
Image Source: Vectors from studiogstock on Freepik

High Utilization

- Reduction in Discomfort
- Standing makes it easier to move around
- Improves energy & mood
- Body Cues lead to adjusting posture
- Coworker utilization of desks (support / influence)
- Feels like a change of scenery
- Standing is normalizated
- Annoying Transition of Desk
- Worried about distrubing others

- Increased Productivity / Focus when Standing
- Easy & Smooth Transition
- Active Company Environment
- Access to privacy when using desk
- Common use by supervisors
- Aware of effects on health
- Standing too much (Makes up for lack of PA)
- Increased visibility of screen

High Activity Profile

Full time employee who has an eletric sit-stand desk both at his place of work and at his home. Both were provided by employer, desk at home upon request.

Full time employee who has an manual sit-stand desk at his home. Desk was provided by employer upon request.

Full time employee who has an manual sit-stand desk at her place of work. This was provided by her employer upon request.

Self Promoted
Desk aquired / requested by user.

- Increased alterness when standing
- Easy & Smooth Transition
- Making transition during breaks
- Feelings of Guilt
- Reduction in Discomfort
- Transitioning interupts work flow
- Increased visibility of others
- Fear of Decreased Productivity / Focus
- Office is not adapted to sccomodate desks

- Task-Oriented Transitions
- Increased social interaction
- Improves energy & mood
- Coworker utilization of desks (support / influence)
- Static company culture
- Forgetting to change position
- Discomfort / fatigue from standing
- Sitting is just more comfortable
- Poor Desk Design

Full-time employee who has an electric adjustable sit-stand desk at is home. She purchased the desk herself.

Full time employee who has an electric adjustable sit-stand desk both at his place of work and at his home.

Part time employee who has an electric adjustable sit-stand desk at his home office.

Low Activity Profile

● **Facilitators**   ● **Barriers**

● ● **Larger Size = More often mentioned**

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The Key Differences

After analyzing the four profiles, it became apparent that there were several key differences between the high and moderately active profiles and the low and not active profiles. These differences often contradicted one-another showing that these factors have a great influence over whether or not a working adult is able to reduce their sedentary behavior and utilize the sit-stand desks.

Each profile had different levels of barriers and facilitators that influenced their sit-stand desk use, and as activity levels progressed up the scale, several tools appeared that aided working adults in adopted their sit-stand habits. These differences and the design opportunities that they present are shown in Figure 13.

The Main Barriers

Barriers to adjusting the desk height to the standing position were most often felt by participants falling into the low and no activity profiles. These main barriers are described below.

Sitting is a habit.
As mentioned in the section "Altering the Sitting Behavior," changing behavior and forming a new habit can be a challenge that typically involves a set of steps that take place over time combined with the motivation to create the change. If this motivation lacks, as it did with many participants, taking action and maintaining the new behavior can be difficult.

Working in a static environment & lack of use by coworkers.
A static environment is considered an environment where most people remain seated, and this position is often related to a person's productivity. Participants often adjust to the environment that they are in, so if this environment is static and their coworkers also do not utilize the sit-stand desks, participants stated that they would remain seated.

Psychological discomfort.
Individual behavior is often influenced by social norms and interpersonal relationships, and stepping out of this norm can typically cause a sense of psychological discomfort. This was mentioned by participants as the idea of being the only one, or one of the few standing, would feel awkward and weird, particularly because they would become more visible.

Fear of decreased productivity and breaks in the workflow.
One of the most mentioned barriers was that participants often chose to remain seated as they believed that transitioning to the standing position would result in a break in their workflow and a decrease in productivity. This aspect is contradicted by participants falling into the more active profiles as they often felt that standing increased their energy levels and productivity.

Lack of awareness of sit-stand transition benefits.
Many participants were unaware of the benefits that altering their position could have both physically and mentally and instead focused on the potential discomforts that could occur. They were less self-aware of what their bodies needed and often considered any pains they felt while sitting as normal and chose to ignore them. Participants in the behavior change process who had started to alter their desk height more often, often noticed that they became more conscious of how their bodies were feeling and the pains they experienced while sitting, something they had not noticed as much before.

Lack of awareness of proper sit-stand practices.
Participants often had an all-or-nothing belief, where they thought that if they did use their standing desks ,then they needed to use the desk in the standing position for a majority of the day. This idea deterred many participants as they were worried about the discomforts that would come from standing so much.

Many of the additional barriers mentioned by the low and no activity user profiles were also experienced by the moderate and high activity user profiles, but often these barriers

did not affect their holistic view of the desks or limit their use. These barriers were left out as they did not present themselves as the key issue for change since even if they were adjusted, the other barriers would still be in place for the low or no activity profiles. These barriers include desk design, the long transition, the noise of the desk, and increased visibility of their screen.

The Key Facilitators

To promote sit-stand desk use and reduce the experienced barriers, high and moderately active sit-stand desk users were also interviewed. These interviews provided insights into what key tools, or facilitators, worked for these users when developing the sit-stand behavior. The goal of finding these key tools is to determine what elements differ in these user's experience with their sit-stand desks and what elements should be incorporated in the final product to promote the transitions between sitting and standing.

Social support and an active environment.
Social support or influence was often the initial factor that influenced participants to try out using their sit-stands desks in the standing position. Often when participants saw a coworker or supervisor using their standing desks, they decided to try it out as well. This factor was also reinforced by having an active environment where using the sit-stand desks was normalized and psychological discomfort from using the desks less apparent.

Body and mind and cues for transition.
Once a participant was able to take up the sit-stand habit, they often became more conscious of their physical and mental state and how working in different positions affected it. They could then use these as indicators for when it was time to transition to a new position.

Task-based transitions.
Although this was a transition method not mentioned by the high and moderate activity user profiles, it was a common recommendation by the low or no activity profiles. Since the break-in workflow appeared to be a significant barrier, many participants believe that they would be able to alter their desk height if it correlated to the start or end of a task.

Reminders.
The need for reminders or triggers is an important aspect for all participants who have not yet fully developed the sit-stand habit. Many participants mentioned that they often just forgot to make the transition and having reminders would help them.

The Limitations of a Digital Reminder

An element that is important to note is that several of the participants in the low activity and moderate activity profiles had previously downloaded or used applications that provided notifications for when it was time to alter between sitting and standing. All of these participants stated that this type of notification did not end up working for them long-term since they eventually began to completely ignore it or "click" out of it without realizing it. Many of these notifications were also considered annoying resulting in users un-installing the apps completely. One of the reasons some participants thought this happened was because their hand was already on the mouse, so it did not require any effort to just close the notification.

For this reason, alternative solutions to digital reminders should be considered.

Figure 16: The key differences between profiles.

Profile of
The Working Adult

Through user research it has been confirmed that there are many barriers preventing working adults from utilizing their sit-stand desks and decreasing their sedentary behavior in the workplace. These barriers do not affect everyone, and it is important to understand the tools that aided the working adults in developing their sit-stand behavior. According to the research, the main tools are **social support** and an active environment where sit-stand desks are commonly used and **body and mind cues**, where a working adult is able to check-in on how they are feeling and transition the height of their desk accordingly.

An additional tool, suggested by many of the participants falling into the low and not active profiles, was **task-based transitions** where the height of the desk could be altered following completion of a task or before a break. Users believed that by utilizing this tool, it would reduce the annoyance of transitioning the desk and would break their concentration less often.

Study Limitations

In the user research study, only six participants fell into the Low or Not Active profiles. These profiles were the most essential as they are the primary users for consideration in this project. Although Karris & Artis (2000) state that qualitative research with five participants from the same homogeneous group can provide up to 80% of the user problems, the limited number of participants from the intended target group could have skewed the results or lead to missed insights. In addition, most of these participants fell under the age of 30, potentially skewing the results as not all individuals in the target age group were included.

Personas

During the user study, participants were interviewed and many insights were gained into the user's typical experience with their sit-stand desks. To aid in exploring user needs and behaviors and narrow down the target group, two persona profiles were created. These profiles combined insights gained from several users and focus on the working-adults who are not active sit-stand desk users.

For these persona the following factors remained consistent:

- Young professionals between the ages of 23 - 35.
- Desk-based for at least 6 hours of the day
- Are able to work from their office for a majority of the weekly workdays
- Have access to sit-stand desks for the entire workday

SHAWN

Rare to No Sit-Stand Desk Use

| ABOUT

- 🎂 25 years old
- 💼 €60,000 - €70,000 / year
- 💼 Mid-Level Engineer (45h/w)
- 📍 Rotterdam

| THE DESK

A few months ago, Shawn began working at a new company that had already implemented eletric sit-stand desks in their office. Shawn rarely uses his desk in the standing position and has noticed that only two people in the office actually do.
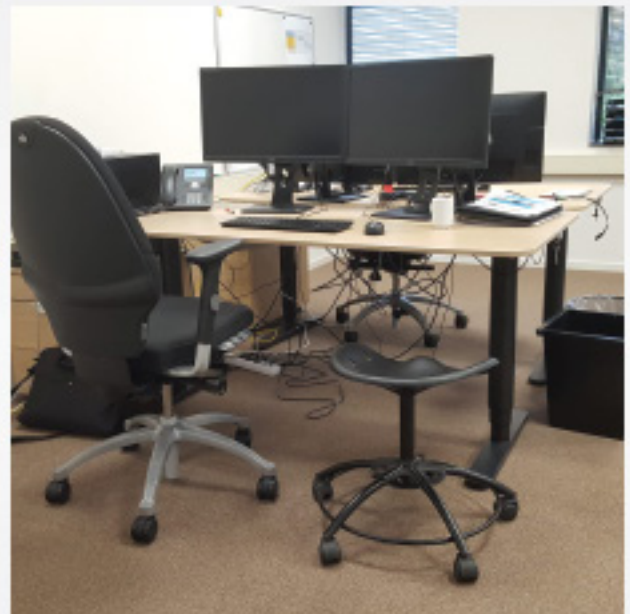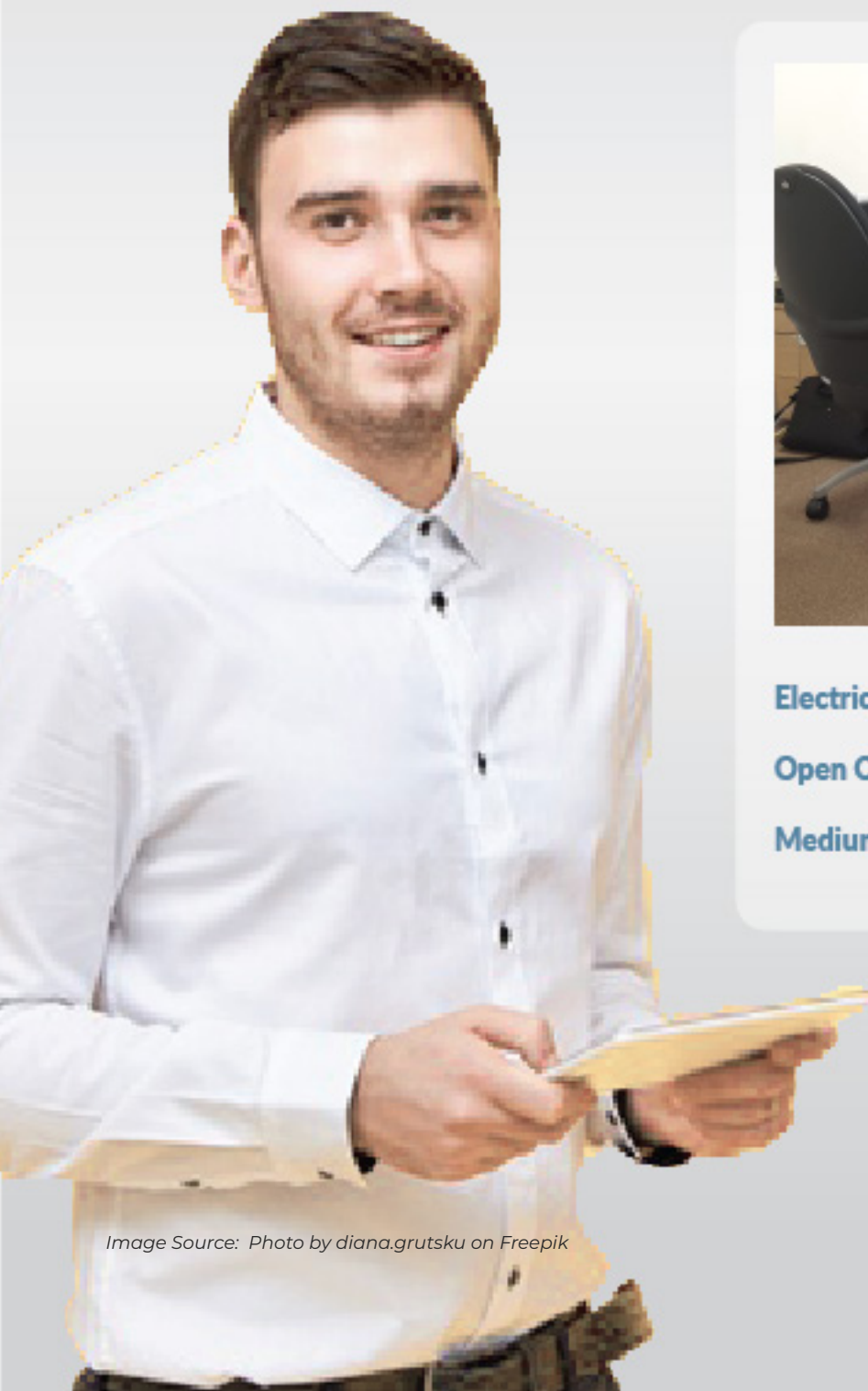
Electric Sit-Stand Desk

Open Office Workspace

Medium Sized Company

"At the office one person stands up, but the rest of us remain seated"

MOTIVATION

Shawn understands that his sedentary behavior at the office probably isn't good, but he hasnt felt any pains from it, so doesn't feel it is a habit that he needs to change. The few times he has altered the height of the desk were during breaks where he could change the height, go for a coffee, and then come back and use it.

Shawn doesn't like the idea of a product that would force him to change his position. He wants to be able to remain in control and have autonomy over deciding whether he will stand or not.

DILEMMAS

Shawn's two coworkers who do use the desks in a standing position are often in this position for most of the day. He has develop and all-or-nothing mentality and does not think his body could handle standing for such a long time. Therefor, he choses to remain seated as it is more comfortable. One of the few times Shawn decided to try to adjust the desk, he felt awkward because he was worried that transitioning the desk would be distracting for his coworkers. As he is relatively new to the company, he limits his use to also ensure he doesnt affect anyone else's work.

CORE NEEDS

Shawn works in a relatively static environment and needs to feel at ease to use his desk without the psychological discomfort that comes from distracting others. He also needs a push to change his habit as it may not be affecting him now, but it could in the future.

TYPICAL WORKDAY

- Bike to the Office
- Arrive & Grab a Coffee
- Morning Meeting
- Work at Desk
- Lunch
- Work at Desk
- Quick Break
- Work at Desk
- Bike Home
- Watch TV or Play Video Games

Standing 10%

Sitting 90%
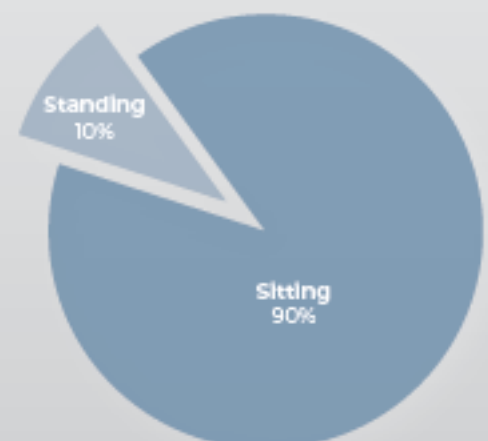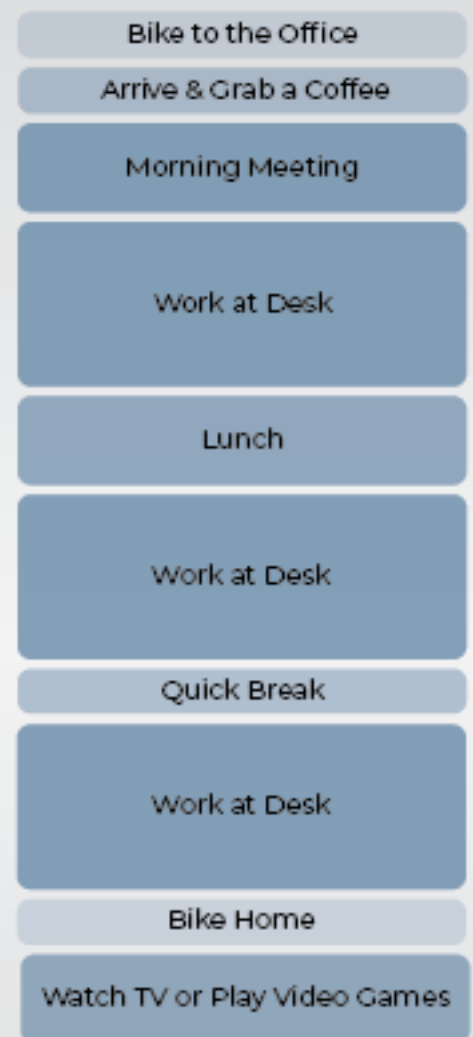
STEPHANI

Low Sit-Stand Desk Use

| ABOUT

- 🏢 31 years old
- ✉️ $ 40,000 - $50,000 / year
- 💼 Product Design (45h/w)
- 📍 California

| THE DESK

Stephani is currently working from home due to the Covid Pandemic and has made a decision to buy an manually adjusted sit-stand desk for herself. Her initial reasoning behind buying the desk was because she was feeling pain in her shoulders and had read that using a sit-stand desk could help with this. Stephani also has a sit-stand desk at her office, but rarely uses it when she is there.
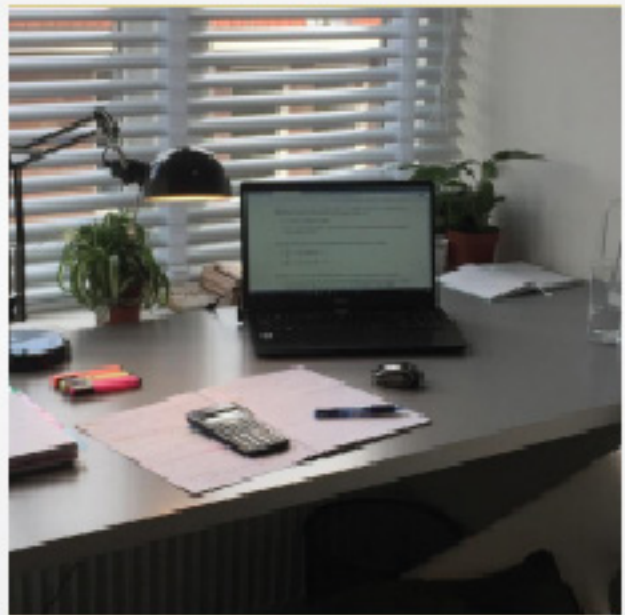
Manal Sit-Stand Desk

Home Office Workspace

Medium Sized Company

"Standing is probably the most important posture, but also the hardest to get to."

MOTIVATION

In the beginning, Stephani used the desk in both the standing and sitting position and found it to help with her should pains. But after a while she didnt feel the pain as intensly and slowly used the desk in the standing position less and less. When she does use the desk, she will alter it based on the tasks she has that day, such as standing for meetings and sitting for reading documents.

DILEMMAS

Stephani's biggest worry is that she won't be as productive when using her desk in the standing position as she finds she is able to stay more focused when sitting. She believes standing will only be useful for certain tasks that require a certain level of alterness.

When Stephani does choose to use the desk, it is often because her should pain returns. She is unaware that she can reduce the possibility of these pains occuring if she continues the sit-stand practice, even when these pains arent as prevalent.

CORE NEEDS

Stephani understands the benefits that using the sit-stand desk can havebut lacks the motivation to really make this change and adjust to working in the standing position. She believed that adjusting the desk is best suited for task-based work and a needs a solution that can take advantage of this to encourage her to stand-up more.

TYPICAL WORKDAY

| Make Breakfast and Eat at Desk |
| Work at Desk |
| Quick Coffee Break |
| Work at Desk |
| Lunch |
| Work Meeting (Stand-up) |
| Work at Desk |
| Long Walk |

Standing 20%

Sitting 80%
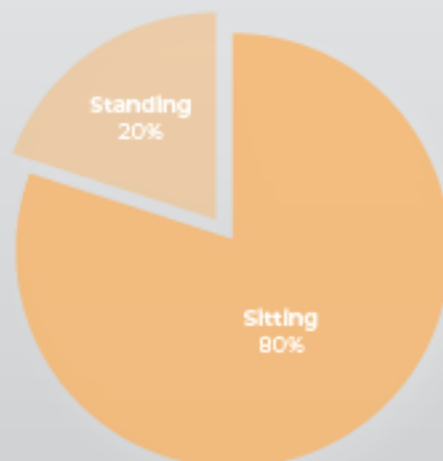
CONCLUSION: THE WORKING ADULT

Through the user research with working adults, the conclusions created during the literature analysis were verified, and further insights about the facilitators and barriers which influence sit-stand desk use were found. During the interviews, it became apparent that the participants fell into four main user profiles concerning their self-promoting sit-stand desk behavior: high activity, moderate activity, low activity, and no activity. The different participant profiles provided an overview of different user experiences and presented the areas for improvement and design opportunities.

The key design opportunity lies in the need to normalize the use of sit-stand desks in the workplace by utilizing the key tools that enable the high activity and moderate activity users to adopt this behavior.

The key tools considered are:

- Social Support
- Body and Mind Cues
- Task-Based Transitions
- Reminders
- Awareness of proper use

By combining aspects of these elements, the goal is to provide users with the support they need to create a change in their behavior.

Boundaries

According to the user research, participants mainly fell into two groups where half of the group chose to use the desks often and the other half did not. For this project the following boundaries were set:

1. The target group will focus on working adults who have a more difficult time adjusting / developing the sit-stand practices.
2. The target group will focus on individuals who are already interested in forming the new behavior, not those who have no interest.

The second boundary is set because in order for behavior change to occur, the individual must already have contemplated making the change. If the individual does not want to change or believe they need to change, they will be much more resistant. But by seeing their coworkers making the behavior change first, there is a likely chance that the individual will start to contemplate it as well.

Requirements

After analyzing the typical step required for habit formation and behavior change the following requirements are set in place:

1. The final solution shall incorporate the elements of habit formation (trigger, action, variable reward, investment)
2. The final solution shall promote the three basic psychological needs for motivation (autonomy, relatedness, and competence).
3. The final solution shall consider alternatives to digital reminders

06
THE MARKET

The following section provides a brief overview of the current market and the existing products aimed at reducing sedentary behavior and promoting physical wellbeing in the workplace. This analysis aims to analyze the existing market to determine who the competitors are and the pros and cons of their current products. The goal is to find a potential market gap and explore product opportunities for the final solution.

Contents

THE COMPETITIVE ENVIRONMENT

To account for employee safety and wellbeing, many laws have been set in place, such as The Dutch Working Conditions Act, which requires employers to ensure that employees are accounted for on a physical, cognitive, and organizational level. To respond to these requirements, employers are implementing new wellbeing practices into their workplace, and whole industries are focused on developing a wide range of digital and non-digital offerings to aid in this process. Among these offerings, there is a focus on promoting physical well-being by reducing sedentary behavior. For this project, a focus is placed on the sit-stand desks and the products meant to motivate employees to utilize the desks as they are intended for. The following figure presents an overview of companies who fall into the market category of the intended solution.

Environment
Office Wellbeing

Industry
*Sit-Stand Desks /
Active Furniture*

Market
(Digital)
*Promoting Sit-
Stand Desk Use*

Market
(Physical)
*Promoting Sit-
Stand Desk Use*
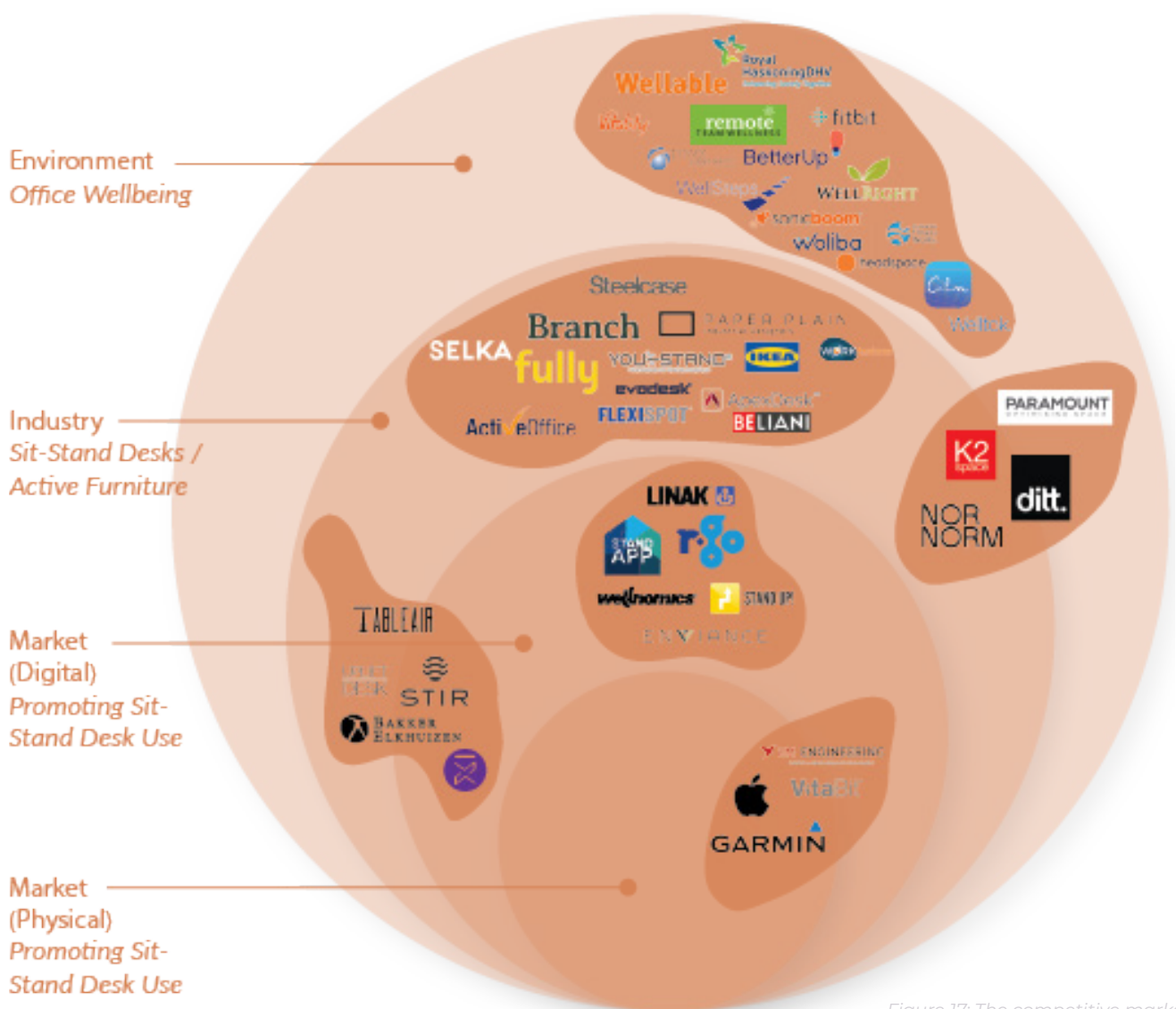
Figure 17: The competitive market

Operational Environment: Workplace Wellness

One of the fastest-growing marketplaces in the world is the wellness industry with a $4.2 trillion market estimated to make up more than 5.3% of the global economic output and is almost half the size of the entire global healthcare market. A growing segment of this market is workplace wellness which was an estimated $47.5 billion market and is increasing at 4.8% each year (Bersin, n.d.). Since before the pandemic, there has been an explosion in the demand for employers to take action in promoting employee wellbeing both in and out of the workplace. This need correlates to the increasing mental health and burnout epidemics affecting working-age adults in many different countries. This has been further enhanced by the different laws establish in various countries that require the employer to ensure that their employees can work safely and healthily. To account for this change in the workplace, there have been many new companies and developments meant to promote wellbeing in the workplace. Since the start of the Covid Pandemic, the loneliness epidemic has been added resulting in an increase in employees' desire for a sense of belonging and community within their workplace.

Industry: Sit-Stand Desks & Active Furniture

Standing desks have been around for a long time but only in the last decades has awareness about the effects of sedentary behavior and the need to reduce it become a prevalent topic of conversation. This conversation has begun to specifically focus on working adults as they are considered to be more at risk due to the prolonged periods of sitting they do at the office. To account for this, many companies have started to produce various types of active furniture and sit-stand desks meant to get reducing working adult's static behavior and get them moving. Although there are many companies now that produce sit-stand desks, few focus on how to get employees to use the desks once they have been purchased.

Here lies an initial market opportunity where there is a possibility to partner up with these companies to provide a tool aimed at motivating users to transition their desks between sitting and standing more often. Some companies aim to provide the same idea, but they are limited and only focus on compatible desks.

Digital Market: Promoting Sit-Stand Desk Use

Within the market, the main method used to promote working adults to use their sit-stand desks as intended is through digital means such as digital applications installed into their desks or on their computers. An example of such companies is Wellnomics and Stir, which provide desks and compatible apps aimed at making the desk transition effortless and providing reminders for when it is time to transition. There are quite a few companies that focus on this area and the pros and cons of some of their products are discussed in the product analysis section.

Physical Market: Promoting Sit-Stand Desk Use

Not considering the actual sit-stand desks, there is a lack of physical products on the market aimed at motivating users to utilize their sit-stand desks as they are intended for. Most companies prefer to focus on using a digital platform for motivation and if they do design a product, the product is often connected to a digital application. This aspect typically allows for the user to easily track their sit-stand progress, set reminders, and receive tips and recommendations towards developing this new behavior. The products which do exist are often worn by the user.

Global Wellness Economy:
$4.5 Trillion Market

Mental Wellness $121b

Traditional & Complementary Medicine $360

Wellness Real Estate $134b

Wellness Tourism $639b

Personal Care, Beauty & Anti-Aging $1,083b

Preventive & Personalized Medicine and Public Health $575b

Workplace Wellness $48b

Thermal/Mineral Springs $56b

Healthy Eating Nutrition & Weight Loss $702b

Fitness & Mind-Body $828b

Spa Economy $119b
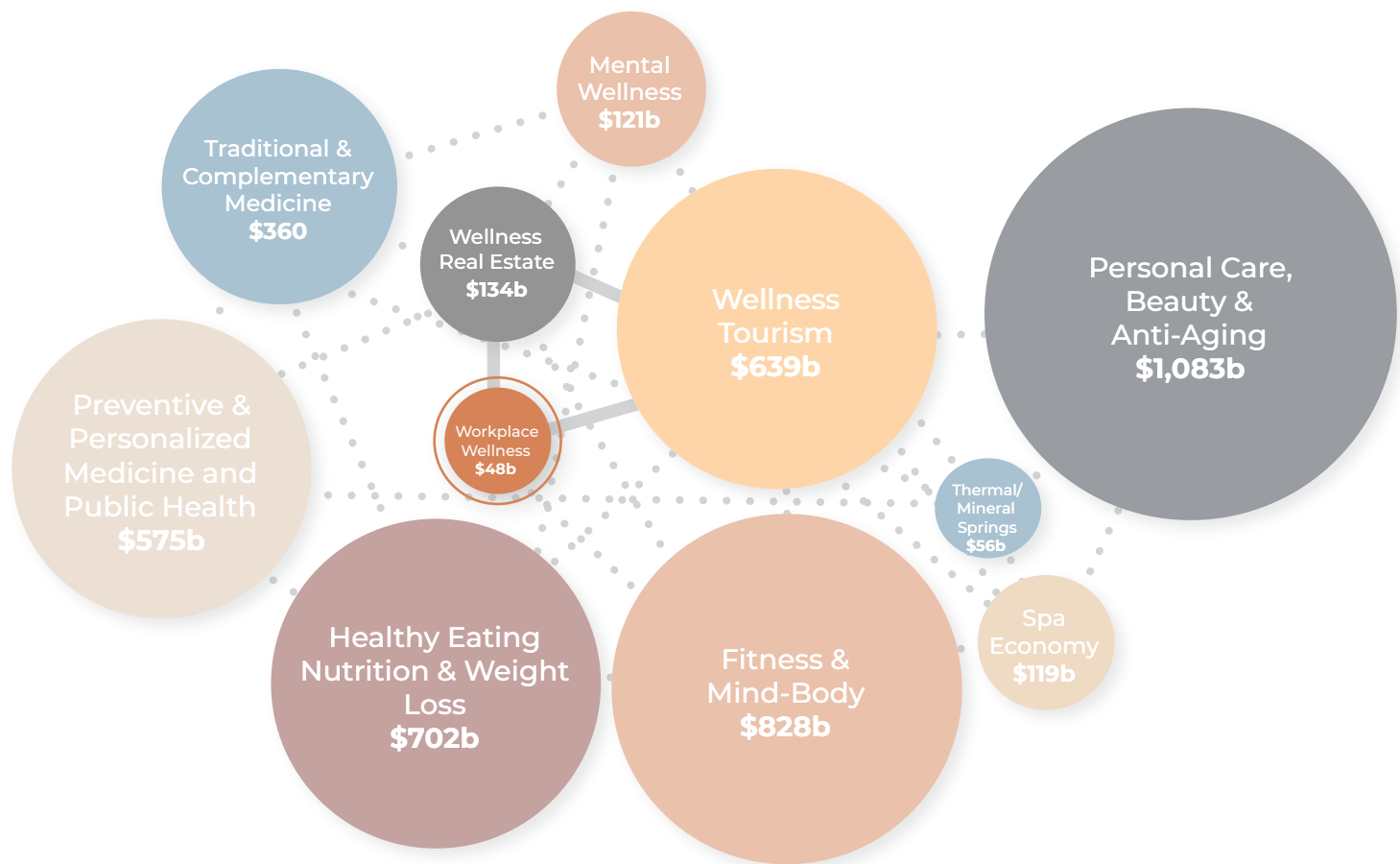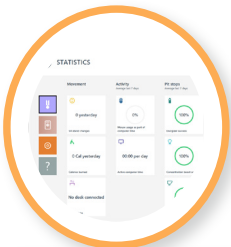
Note: Figure for Mental Wellness is for 2019; figure for Physical Activity is for 2018; figures for all other sectors are for 2017. Numbers do not add to total due to overlap in segments. Dark colored bubbles are the sectors for which GWI conducts in-depth, country-level primary research. Light colored bubbles are sectors for which GWI aggregates global estimates only, drawing from secondary sources.

Source: Global Wellness Institute

Figure 18: The global wellness economy with workplace wellness coming in at USD 48 billion.
Source: Global Wellness Institute

PRODUCTS ON THE MARKET

The following section presents a brief analysis of existing products on the market that are aimed at motivating users to utilize their sit-stand desks. By looking at existing products, a review can be done to see what is missing in competitor's products and consideration of how certain features should be included in the final solution to meet the user's needs.

	VitaBit	Stir Kintetic	Work & Move	Table Air
Price	€120	€2,990	Not Listed (Sold through retailers)	€2,899
Features				
Best	+ Coaching portal + Tailored feedback + Work in groups + Set goals + User specific reminders + Does not require a specific sit-stand desk	+ On-desk controls + Senses presences and shares info with user + Gentle rise and fall of desk as a reminder + Connected & Smart + Auto Login	+ Personalized guidance + Record & save desk heights + User can record data & set reminders + Provides tips Rewards behaviors	+ Record and save persona sitting and standing height + Automatically tracks standing progress + Smart button to alter height
Worst	− Tracker must be carried on person − Requires Charging − Still in development (not on the market)	− Expensive − Must purchase entire desk − Screen resolution is not great	− Rewards are confusing & not associated with specific behaviors − Only compatible with Linak and LOGICDATA's sit-stand controls	− Controlled with App − Only has digital reminders − LED lights have no purpose − App is only compatible with specific desk − Expensive
Motivation				
Autonomy	🙂	😐	😐	🙂
Relatedness	🙂	🙁	🙁	🙁
Competence	🙂	🙁	🙂	🙁

Product Comparison

Figure 19 below presents a comparison of nine different products on the market aimed at motivating users to alter between sitting and standing. The products are evaluated based on their price, their best and worst features for consideration, and how they scale in terms of the Self-Determination Theory and Motivation. As shown in the table, products received face icons indicating whether they fulfill each of the three basic psychological needs required to motivate humans.

There are several areas for consideration when designing the future product. First, many of the products that exist today are only compatible with specific desks. This means that if a user wants to use the product, then they have to purchase the compatible desk as well. Second, many of the products involve the use of a digital notification from a smartphone application. This aspect will require users to keep their phones with them at all times and could cause a distraction from their workflow. Third many of the products focus on using a coach-like motivation method, and only one uses a task-based transition method.

Active8 Tracker	StandApp	Stand Up! App	Wellnomics	RSIGUARD
€129 - €149	Free App	Free / Paid Version App	Free App	€56
+ Smart & Connected Personalized Coach Dashboard **+** Access to Groups **+** Can connect to third part hosts **+** Creates awareness about lifestyle and activity	**+** Reminders to stand **+** Includes 30 low to medium exercises user can do at work **+** User sets the reminder	**+** Digital reminder **+** Customizable for work schedule **+** Records data and tracks progress **+** Limits alarm to office location **+** Interactive notifications	**+** PC Reminders with pop-up notifications (easy to ignore) **+** Posture change coach tailored to user **+** Progress tracking	**+** Provides awareness **+** Micro break reminders **+** Sit-stand reminders **+** Guidance on posture and monitor placement **+** Uses keyboard to control desk
− Must be worn on person **−** Not specifically focused on sit-stand behavior **−** Mainly meant for tracking progress & feedback	**−** Controlled with App **−** No habit change support **−** Easily ignored **−** Only available for Apple products	**−** Controlled with App **−** Only compatible with specific desks **−** No habit change support **−** Easily ignored **−** Not aesthetically pleasing **−** Only for Apple	**−** Only digital **−** Lacks support **−** Only compatible with specific desks **−** Old school layout **−** Notifications are easy to ignore & annoying **−** Does not open	**−** Only digital and works on desktop **−** Lacks support from peers / relatedness **−** Old school layout, not user-friendly

Figure 19: Analysis of current products on the market.

CONCLUSION: MARKET ANALYSIS

Through the brief market analysis and product evaluation, it is apparent that workplace wellbeing is a growing market with more and more companies taking part. Although this is a growing field, there is still a lack of companies focused on designing user-centered solutions that are aimed at aiding working adults in altering their behavior and using their sit-stand desks more often. Through this analysis the following gaps were noted:

There is a lack of motivational products that are desk-based solutions and do not require compatibility with specific sit-stand desks. This is seen in the products as a majority of the solutions consisted of smart desks, wearable devices, or apps that are only compatible with specific desks. This means that working adults who already have access to sit-stand desks would either have to purchase a new desk or only use the "beta" versions of the apps.

There is a lack of products aimed at ensuring a sense of relatedness and support among it's users. Although this basic need is often not utilizing, it is extremely essential as social support and acceptance is a key tool in behavior change practices.

The digital reminders used by many of the products were easy to ignore or annoying. Since the reminders were on the phone or computer, they were often easy to click out of and forgetten, resulting in no change of posture. Personal testing of several of these digital products proved this to be true. This correlates to comments made by several of the participants in the user research.

Requirements

Based on these findings, several design requirements are established.

1. The final solution shall be compatible with all types of sit-stand desks
2. The final price should range between 50-120 USD

By setting this requirement, the final solution shall be usable by working adults who already have access to manual and electric desks and they should not be required to purchase an entirely new desk to use the product to its fully capacity.

DEFINE

NARROWING DOWN THE SCOPE

07

DESIGN FOCUS

Contents

THE
CURRENT CONTEXT

Desk-based work has been around for centuries and although the physical workspace has changed and been modernized, it is still mainly comprised of a desk and a chair. But as the workspace has changed, so has the type of work being done. Over the past decades, there has been a progressive switch from physically demanding tasks to knowledge-based work (Panahi & Tremblay, 2018). This has resulted in a shift in the activity profile of individuals as physical activity has been replaced with cognitive work and there is a significant increase in our environments being (re)engineered for sedentary behavior. This increasing rate of sedentary behavior has emerged as a critical area for intervention, as prolonged sitting is proven to be correlated to an increased risk for adverse health effects such as cardiovascular diseases and musculoskeletal discomfort (Altenburg et al., 2019).

Sedentary behavior is on the rise and working-age adults are at high risk
Today humans are spending increasing amounts of time in environments that not only limit access to physical activity but also promote sedentary behavior. Humans are meant to move and by minimizing their movement and increasing the periods spent in a static position, there is an increase in the risk for all-cause mortality, cardiovascular diseases, musculoskeletal disorders, among other things. The rise in sedentary behavior is increasingly apparent among desk-based working adults as they often take part in prolonged periods of static sitting while working behind their desks at their computers. Often these individuals also return home to spend their evenings relaxing and in the same position.

As employers aim promote their employee's well being both in and outside of the workplace, more and more companies are investing in sit-stand desks.
The workplace culture is changing and as the mental health and burnout epidemics have been deemed "occupational phenomenon," there has been an explosion in the demand for employers to promote employee wellbeing both in and out of the office. The workplace wellbeing movement has become one of the biggest conversions as people are becoming more health-conscious and new working condition acts are coming into effect. One area in which employers are beginning to take action is in the area of promoting employee physical wellbeing by reducing the sedentary environment of the workplace. To do this, employers have provided wellness programs, gym passes, and active furniture among other things. One of the most popular methods is the implementation of sit-stand desks that enable working adults to transition between sitting and standing while remaining at their desks.

Sit-stand desks provide many benefits.
If used properly, sit-stand desks can provide working adults with many benefits physically and mentally. These desks are meant to aid users in easily altering their position to ensure that they do not remain in a static state for too long. To use the sit-stand desks correctly, it is important that the user transitions between sitting and standing, rather than just remaining in the standing position (as some users believe). By utilizing these desks, studies have shown that individuals often feel a reduction in their musculoskeletal discomfort, are at lower risk for cardiovascular diseases, develop a lower waist circumference, lower their blood sugar levels and risk of type 2 diabetes, and often feel an improvement in their mood, energy levels, and overall

productivity.

Even as working adults gain access to sit-stand desks, there is a lack of utilization and working-adult remain seated.
Although the benefits of using sit-stand desks to adjust posture have been recognized and companies are increasingly installing these workstations in their offices, studies indicate that there remains to be a general low utilization of the desks among working adults. Despite their initial enthusiasm at receiving the desks, employees often forget or lack the continuous motivation to switch to the standing position and end up sitting more than they initially intended. There are many reasons for why this occurs but the most prevalent factor is that sitting is a habit and is often considered a social norm that people are not fully aware of the side effects of. Changing a habit is difficult and when changing that habit goes against the workplace norm (e.g. static environment) it can often result in psychological discomfort as most people would prefer to fit in and stick to the norm rather than be the only one, or one of few, standing out.

There is a need to normalize the use of sit-stand desks in the workplace (particularly standing)
Currently, in many offices, standing is not normalized resulting in the static nature of the office and diminishing ideas of using the sit-stand desks in the standing position. But in offices that provide an active environment and use of the sit-stand desks is common, standing has become the norm, and seeing coworkers or supervisors use the sit-stand desks often influences employees to also reduce their sedentary behavior. To transition from a static environment to an active environment where standing is normalized, employers cannot only implement the sit-stand desks but need to follow through by providing a solution that is tailored to aid their employees in making the behavior change.

Working adults seem to need support to make this transition
Although the workplace environment must change to support and normalize a sit-stand culture, behavior change is often a personal transition that requires a combination of personalized tools and social support suited to each individual. As found in the user research, some working adults have a more difficult time to adjust to using their sit-stand desks as they are intended for and may need additional tools and support to aid them in taking action and maintaining the sit-stand behavior. By taking the first steps in making this transition, normalization could gradually increase due to the influence of coworkers on one another.

Image Source: Photo by Kathy Katella on Yale Medicine

THE DESIRED FUTURE

In the ideal scenario, transitioning between sitting and standing would be an easy process that has been normalized in the workplace with coworkers supporting one another to make the positive change. All working adults would be aware of how the benefits of the transition affect their physical and mental state and would be able to rely on these self-aware body cues as the reason behind their change in posture. The design opportunities described below present the direction for the final solution shall take fall in line with the set requirements and boundary considerations.

Design Opportunities

The design opportunities described below present a summary of the results from the literature and user research and focus on how to promote and normalize the use of sit-stand desks in the open office workspace. The opportunities are based on the key facilitators of highly active sit-stand desk users and consider that behavior change is a personal process that requires support. These design opportunities provide a base for moving forward in the design process and are considered during the brainstorming sessions, concept development, and concept evaluations.

Increase Sit-Stand Awareness
The first stage in behavior change is awareness of the problem and knowledge of how to make the change. In the case of sit-stand desks, users need to increase their awareness of both the negative effects of sedentary behavior as well as how to use sit-stand desks in a way that is the most beneficial for the human body and mind. One of the basic psychological needs is competence and people need to understand why they are doing something to gain mastery over it

Promote Social Support
Peer support is a key method use to increase motivation and understanding among users. The primary reason people initially perform certain actions is because the specific behaviors are promoted or modeled by significant others to whom they want to feel related. By promoting a team-like atmosphere, coworkers can support one another towards using the sit-stand desks more often.

Increase Body & Mind Awareness
The body and mind are powerful tools that are often ignored. Participants who are active sit-stand desk users noted that they became more conscious of how their bodies were feeling once they picked up the habit and were able to use physical and mental cues as indications for when it was time to stand up for sit down. By designing to aid users in becoming more self-aware of what their bodies are telling them, there is a good chance that they will begin to notices the discomforts that occur due to prolonged periods of static change and attempt to alter their position to relieve themselves of this discomfort.

Design for Task-Based Transitions
Often the low-activities profiles believed that certain tasks could be better done sitting while other tasks could be better done standing. This related to the mental state that the task required (e.g. standing during meetings if you need to be alert or sitting while reading a report to feel more relaxed). Although participants did not often do this themselves, they believed that by specifying tasks for standing and tasks for sitting, it would motivate them to adjust their position more often.

Key Criteria for the Final Product

The criteria for the final product shown in Figure X. These requirements combine those specified following the literature analysis and user research and the results of the Product Journey Map included in Appendix V. These requirements are inspired by the Process Tree and List of Requirements proposed in the Delft Design Guide.

Some of the following requirements are taken into consideration throughout the ideation and concept development process and others are used for evaluation of the final solution. Some of the requirements have sub requirements to further specify what they mean.

Set-Up

1. The initial set-up/installation should not take longer than 10-15 minutes *[Demand]*
2. The Final shall be easily accessible by the user ~ 64 cm away max. *[Demand]*
3. The product shall be easily integrated into the user's workspace *[Demand]*

Design

4. The final solution shall incorporate the elements of habit formation (trigger, action, variable reward, investment) *[Demand]*
5. The final solution shall be easily packaged and stored. *[Demand]*
6. The final product shall be easily transported to account for the hybrid work environment *[Demand]*
7. At least 50% of product should be made of sustainable / recyclable materials. [Demand]
8. A prototype can be built within the thesis time frame *[Wish]*

Performance

9. The total daily interaction with the product should not take more than 15min/day. *[Demand]*

10. The product shall be usable during the workday and in the workspace *[Wish]*
    10.1 Not distracting to self
    10.2 Not distracting to others
    10.3 Compatible with all types of sit-stand
11. The product shall reduce the long-term sedentary behavior of working adults. *[Wish]*
12. The product shall promote the transition between sitting and standing, not just standing alone *[Demand]*
13. The final solution shall promote the three basic psychological needs for motivation (autonomy, relatedness, and competence). *[Wish]*
    13.1 User should always feel in control
    13.2 User should develop competence of sit-stand desk use
    13.3 Sense of relatedness with

Maintenance

14. The product should be able to automatically conserve energy when not in use. *[Demand]*
15. It Should be able to charge while in range of user's workstation. *[Demand]*
16. It should be able to be easily taken apart and repaired with common parts. [Demand]

Desirability

17. The final solution shall be affordable to both the employer (on a business level) and the employee (on a personal level) ~ 50 - 60 USD/Year *[Demand]*
18. Users are willing to purchase or receive the product from employer. *[Wish]*
19. The final product should be simple and easy to use *[Wish]*

Boundary Conditions

Eight boundary conditions were set as results of the literature analysis and user research. These boundary conditions are mentioned in the conclusion of each chapter in the literature analysis and are listed below.

1. The solution shall focus on **prevention** rather than intervention
2. The solution shall focus on reducing the sedentary behavior of **desk-based working adults** in high-income countries with a special focus on the United States.
3. The solution shall be usable during the workday and in the workplace
4. The solution shall be designed for a **hybrid open-office/home office layout**.
5. The project will focus on the promoting utilization of **sit-stand desks** in the workplace.
6. The target group will focus on working adults who have a more difficult time adjusting / developing the sit-stand practices.
7. The target group will focus on users who **want to form the it-stand behavior**, not those who have no interest.

"My vision is to normalize the use of sit-stand desks in the workplace by providing working adults with the tools and support they need to reduce their sedentary behavior and form the sit-stand habit"

SYNTHESIS

CREATING THE FINAL SOLUTION

08
IDEATION

When it comes to the working adult and their sit-stand desk use, it became apparent that these individuals fall into four user profiles: highly active, moderately active, low active, and not active. As shown in the conclusion from the user research, participants falling into the highly active and moderately active had two key tools which aided them in facilitating their sit-stand behavior while those in the low active and not active profiles had one key tool that they believed would help them to better develop the habit. These tools were:

1. Social Support
2. Body & Mind cue
3. Task-Based transitions.

The following section presents an overview of the steps taken to evaluate these three tools and determine which features of the concepts presented should be utilized in the final design.

Contents

DEVELOPING IDEAS

The working adult is at high risk for the adverse side effects of a sedentary lifestyle. This is because they spend a majority of their workday sitting behind their desks with limited breaks. Initial user research provided the base tools that the concept ideation was based upon: task-based transitions, social support, and body & mind cues. The ideation session resulted in many ideas, and these ideas were then clustered to create the final three concepts, each utilizing one of the three tools. By testing these tools and features of the concepts, it is possible to determine which provides the most optimal base for the final product. A final clustering / itemized response evaluation is used to combined the best features of each concept into one promising final solution.

Brainstorming

A brainstorm session was held with a group of participants and revolved around generating ideas which utilized at least one of the three tools. The session produced many great ideas which were then clustered and developed upon to form the three concepts. The three concepts and their key features are described in the following sections.
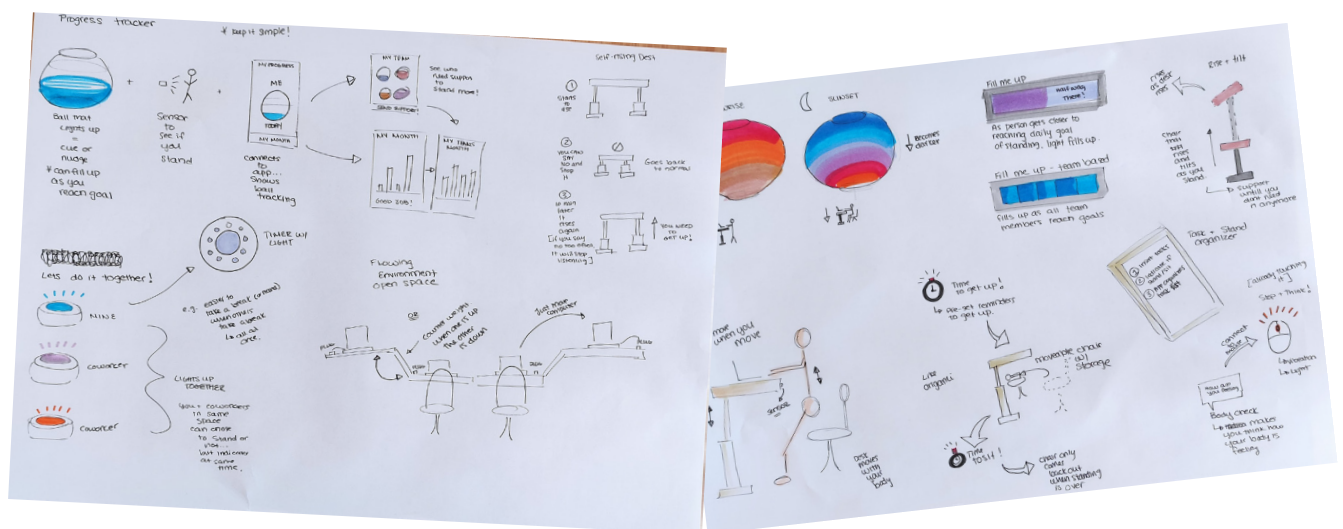

Image Source: Photo by Michal Adar

Idea 1: Desktop Coach

Description

The Desktop Coach is an intelligent virtual coach who brings the user together with a team to set goals, gain support, provide motivation, reminders, and rewards to help the working adult reach their sit-stand goal. At the beginning of each day, the user either sets a personal goal, buddy up and join a coworker's goal, or join the company's challenge. Users have control over the coach by setting which goals they want to achieve and the level of motivation they want to be provided, while also being able to track the long-term progress they are making. The goals presented to the user fall into specific levels, which the user will move up in as they become more competent in their ability to alter their position.

The coach will also provide tips and tricks to help the user develop better sit-stand practices.

Key Tools

— Social Support
— Reminders

Key Features

— An intelligent virtual coach that brings the user together with a team to set and accomplish goals.
— Uses social support as the key motivational factor.
— The Desktop coach provides tips, reminders, encouragement, updates on progress, and rewards when goals and challenges are accomplished
— Only-at-the-office solution which user can sign-in to get their personal data.
— User has full control over their goals.
— Physical tablet placed on desk.

1 Arrive at dest and sign in.

The user arrives at their desk and signs into the DeskTop Coach tablet.

2 Welcome.

Once the user has signed it, the DeskTop Coach welcomes them back!

3 Select a goal.

The user is prompted to set a personal goal, buddy-up with a coworker, or join the company challenge.

4 Challenges are based on progress.

According to the user's previous progress, they are presented with goals that allow them to gradually decrease their static sitting habits with their peers.

5 Preset Reminders.

The DeskTop coach will provide the user with tips, reminders, encouragement, updates on progress, and rewards when goals are accomplished.

6 Team Progress.

The user can check in to see their long-term progress as well as their team's progress on the goal/challenge that they have selected.

7 Preset Reminders.

The DeskTop coach will provide the user with tips, reminders, encouragement, updates on progress, and rewards when goals are accomplished.

8 Team Progress.

The user can check in to see their long-term progress as well as their team's progress on the goal/challenge that they have selected.
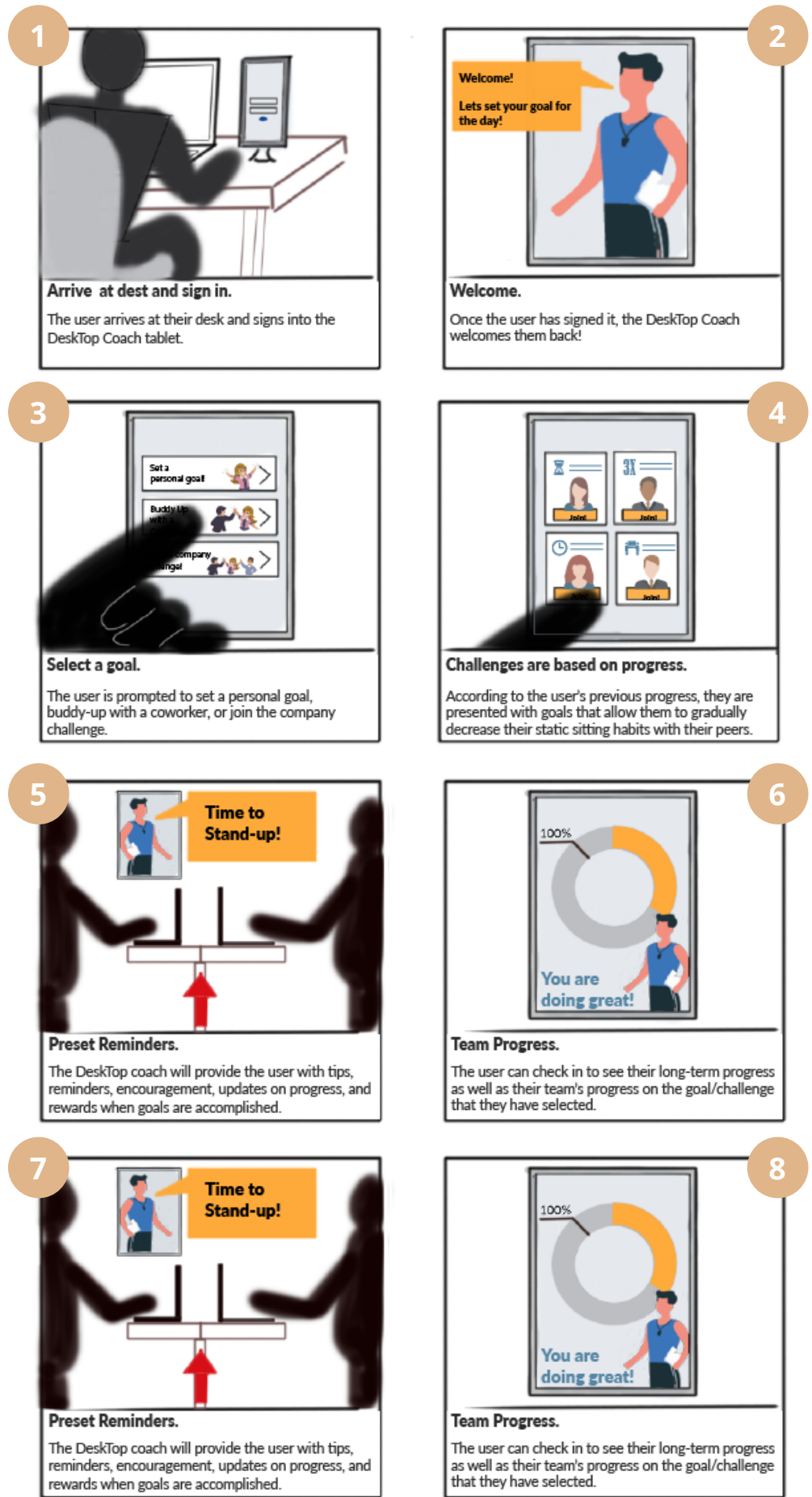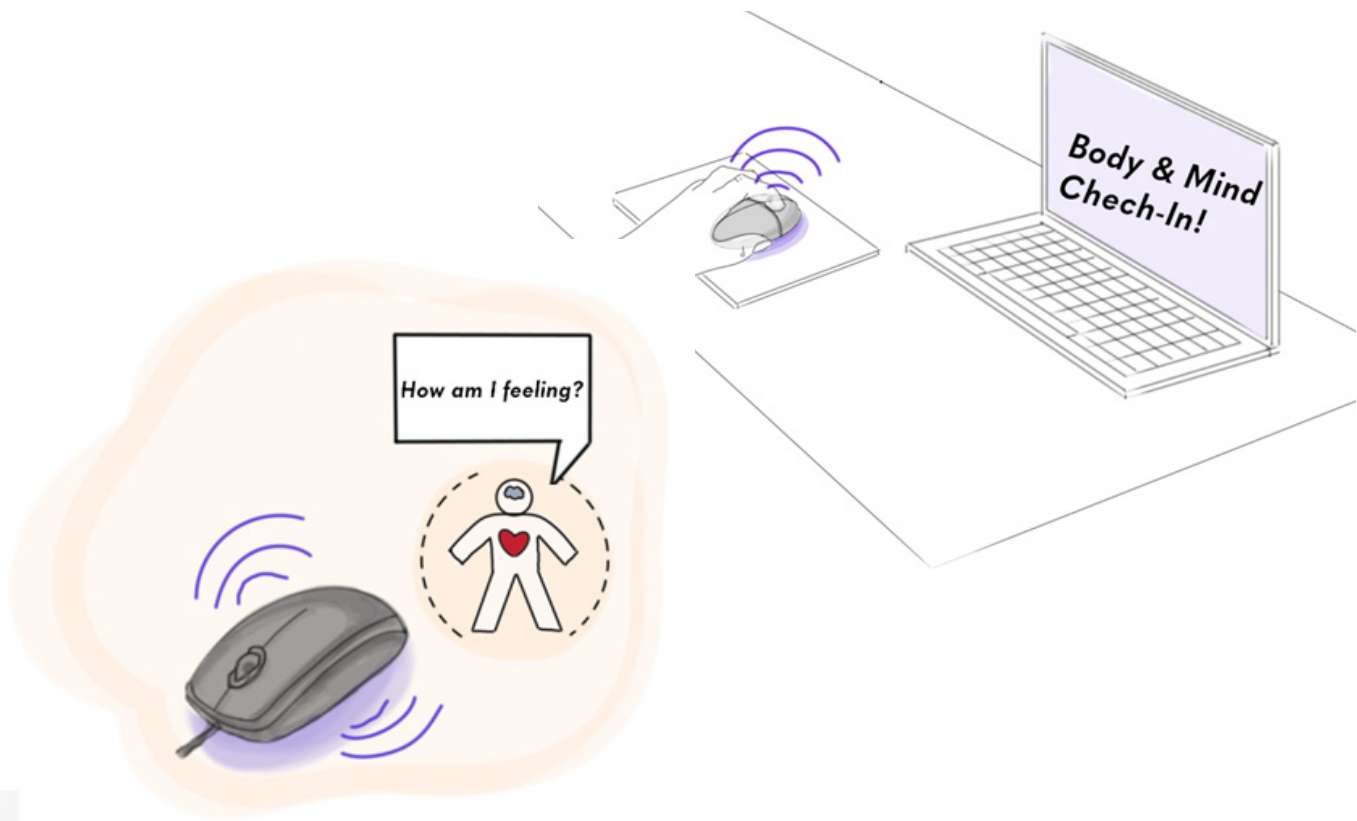
Idea 2: Body & Mind Mouse

Description

The Body & Mind Mouse combines a physical and digital product that takes advantage of classical conditioning to help the user become more aware of their body and mind to notice how they are feeling and then provides tips and tricks on how they can adjust their sit-stand desk to feel better. The product analyzes if the user is sitting or standing statically for a prolonged period or if they are adjusting in a way that indicates they are physically discomfortable. Once this occurs, a cue is sent to their mouse (e.g. vibration or lights), and a dialogue box will pop up on their screen asking them to indicate how they are feeling (both physically and mentally), it will then provide them with tips to alter their posture and desk position, so they can feel better. The goal is that over time the dialogue box will pop up less and less and the user will begin to associate the mouse cues with checking in on themselves and altering their position. The user can also track their answers over time to see the effect that altering their position has on both their body and mind.

Key Tools

— Body & Mind Check-In/Cue
— Reminders

Key Features

— Focuses on the physical and psychological indications for altering position.
— Only-at-the-office solution which user can sign-in to get their personal data.
— Uses AI to analyze user's sitting habits
— Computer Application to provide body & mind check-in, tips and tricks to feel better, and insights into progress.
— Takes advantage of a product which most working-adults already constantly use.
— Uses nudges to classical conditioning to help user start checking-in on themselves and altering according to their body's needs.
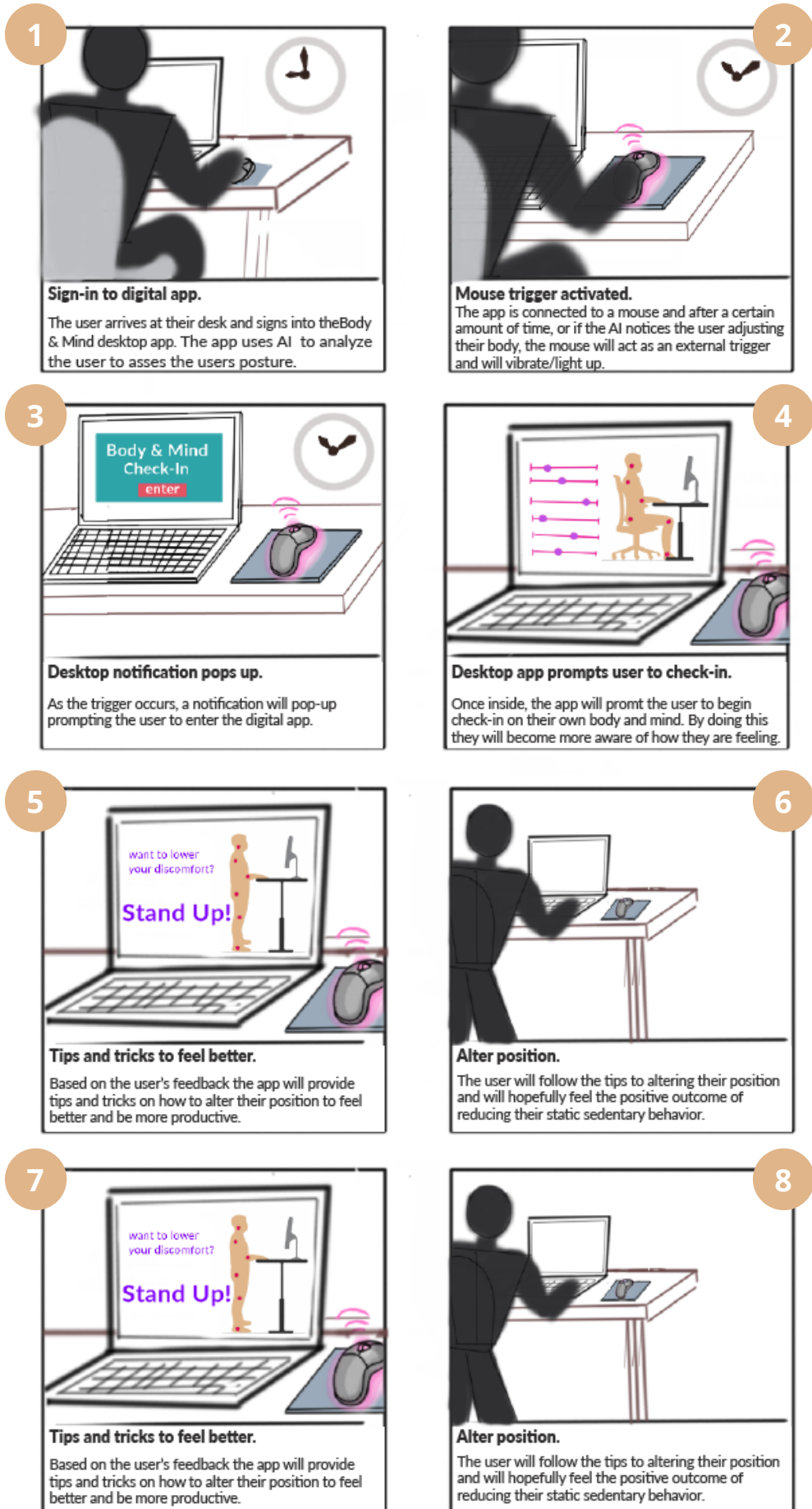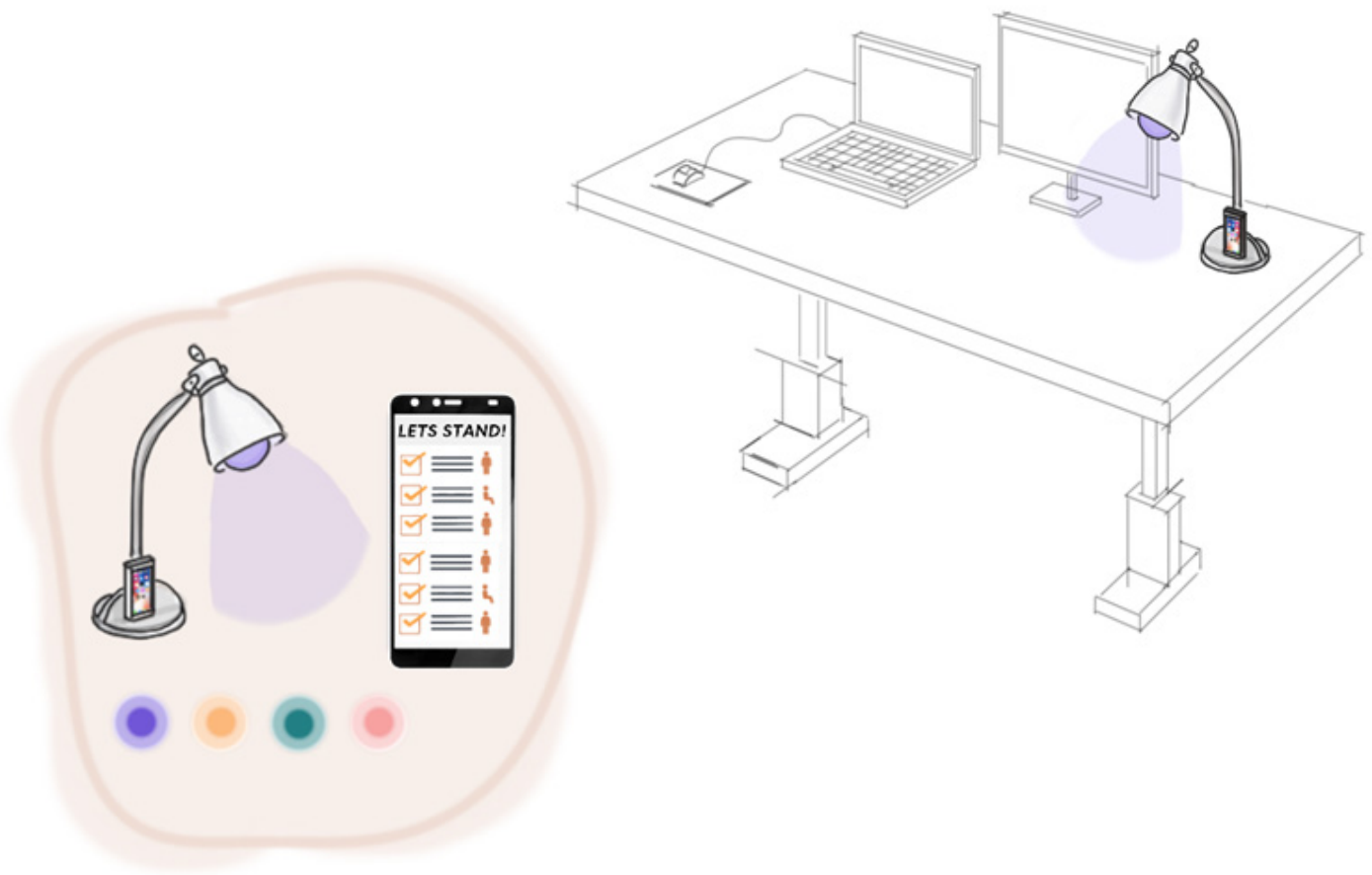
1

Sign-in to digital app.

The user arrives at their desk and signs into theBody & Mind desktop app. The app uses AI to analyze the user to asses the users posture.

2

Mouse trigger activated.

The app is connected to a mouse and after a certain amount of time, or if the AI notices the user adjusting their body, the mouse will act as an external trigger and will vibrate/light up.

3

Desktop notification pops up.

As the trigger occurs, a notification will pop-up prompting the user to enter the digital app.

4

Desktop app prompts user to check-in.

Once inside, the app will promt the user to begin check-in on their own body and mind. By doing this they will become more aware of how they are feeling.

5

Tips and tricks to feel better.

Based on the user's feedback the app will provide tips and tricks on how to alter their position to feel better and be more productive.

6

Alter position.

The user will follow the tips to altering their position and will hopefully feel the positive outcome of reducing their static sedentary behavior.

7

Tips and tricks to feel better.

Based on the user's feedback the app will provide tips and tricks on how to alter their position to feel better and be more productive.

8

Alter position.

The user will follow the tips to altering their position and will hopefully feel the positive outcome of reducing their static sedentary behavior.

Figure 21: Body & Mind Mouse - Storyboard

Idea 3: My SitStand Lamp!

Description

The Self-Management lamp is a task-based digital/product combination that allows the user to insert their day's schedule with the tasks they need to accomplish and when they want to take breaks throughout the day on their phone. The app then asks the user to set a goal and indicate which tasks they want to try to do while standing. The goal starts small (e.g.stand up during their meeting) and gradually asks the user to indicate more and more times when they want to transition their posture until they reach their final goal. Users can also see the goals or tasks that their coworkers have set and choose to "buddy-up" (e.g. stand at the meeting together or alter desk position during each coffee break). Once the daily tasks and goals are set, the user places their phone on the lamp and the data is uploaded. The lamp has different color cues indicating to the user when it is time to change position, alter tasks, or take a break.

Key Tools

- Task-Based / Self-Managment
- Reminders

Key Features

- Smartphone application for setting schedule, tasks, and goals for the day.
- Physical product to provide reminders and cues to desk transitions, tasks, and breaks (limits screen based cues)
- Uses task-based transitions to help user adopt sit-stand practices (Reduces obstruction to workflow)
- Provides gradual transition with users starting small (selected one task to stand during) and gradually increases the number of tasks during which the user stands / alters position.
- The user has control over when they stand.
- Possibility to "buddy up" and join another coworker's set goal/ standing task .
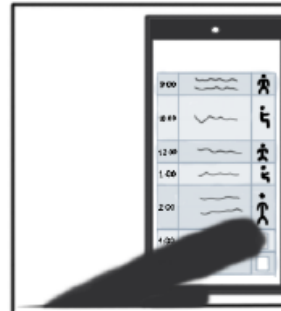- Interaction with an app to upload schedule and tasks and gain insights on progress.

1

Start the Workday.

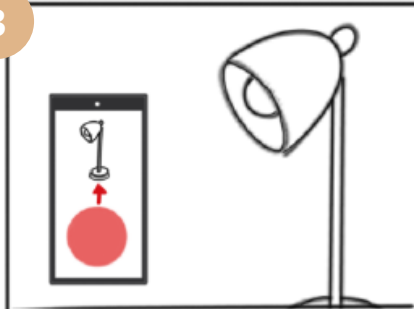The user arrives at their desk and signs into the My Sit-Stand Lamp! App.

2

Enter daily tasks and sit-stand transition.

The user adds their daily task list into the app and decides during which tasks they want to stand or sit for.
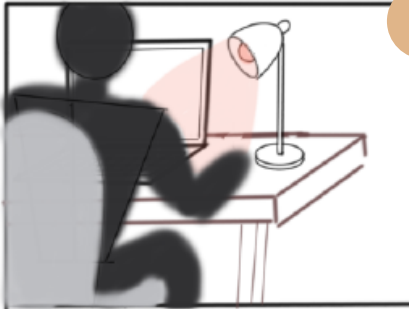
3

Upload to lamp.

Once their schedule has been set, they will be able to upload the data to their desk lamp, which will act as an indicator to help them manage their day.

4

Color cue - time to start next task.

The lamp will have several color cues (preset by the user). One color cue will indicate when it is time to transition to the next task.

5

Color cue - time to stand up.

Another color cue will indicate when it is time to transition the desk to a standing position.

6

Color cue - time to take a break.

Another color cue will indicate when it is time to take a break.

7

Color cue - time to stand up.

Another color cue will indicate when it is time to transition the desk to a standing position.

8

Color cue - time to take a break.

Another color cue will indicate when it is time to take a break.

Figure 22: My Sit-Stand Lamp! - Storyboard

TESTING THE IDEAS

Before evaluating the three concepts and selecting the final direction, the concept's key tools needed to be tested to determine how users experienced them and which would provide the optimal base for the final product. To do this, a user study was conducted where participants were gathered and each tool was tested over 3-4 hours, followed by a concept evaluation where users could compare the three tools and concepts. To select the final direction, an itemized response method was used to judge the ideas and evaluate the positive and negative features of each concept and determine which features should be included in the final product. The following sections present an overview of the methods taken and the results of each testing phase. For a more detailed description of the user testing, refer to Appendix VI.

Phase 1: Testing the Key Tools

Research Objective

The goal of the first phase of this study was to evaluate the three key tools (social support, body & mind cues, and task-based transitions) based on the user experience and their ability to reduce the sedentary behavior of working adults.

Research Question

Which of the three key tools provide users with the best experience when attempting to reduce their sedentary behavior and develop the sit-stand habit?

Methods

To provide the answer to this question, research was accomplished by combining structure observations followed by a group discussion. In this case, participants were split into three groups and each group was provided with a prototype emphasizing the key tool they were testing. At the end of the testing period, a discussion was held and each group was asked to evaluate their experience with the tool.

Participants

Due to the Covid Pandemic, there were restrictions on who could enter the IO faculty for testing. For this reason, nine master students from the IO faculty were used as test participants. These students do not fall into the target group of desk-based working adults, but due to the nature of their study and the fact they are accustomed to prolonged periods of desk-based work, they provided an optimal alternative to working adults.

Participants were divided into three groups, with each group testing a different key tool.

Room Setup

As shown in Figure 20, the study room was divided into three sections with a barrier placed between each section. Each participant group was placed in a section and a desk was set at the front middle of the room for the researcher. This desk placement allowed for easy control and observations.
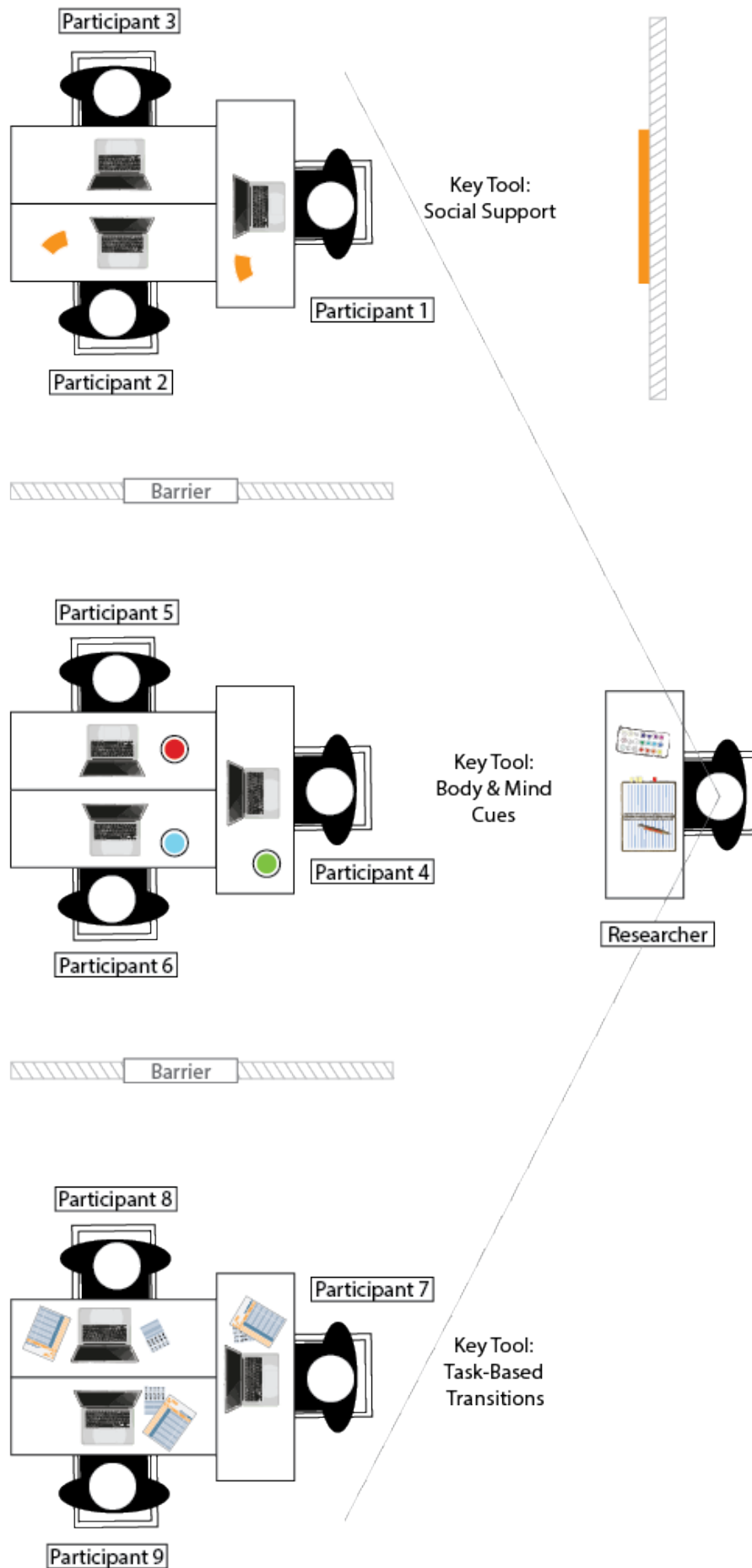
Participant 3

Participant 2

Participant 1

Key Tool:
Social Support

Barrier

Participant 5

Participant 6

Participant 4

Key Tool:
Body & Mind
Cues

Researcher

Barrier

Participant 8

Participant 7

Participant 9

Key Tool:
Task-Based
Transitions

Figure 23: Research through design user testing set up

Stand for 20 minutes at the start of every hour!

Body & Mind Check-In

Click the link below!

Figure 24: Key tool - body & mind check in cue & notification

Figure 25: Key tool - social support, goal and team progress tracker

Figure 26: Key tool - task-based transition schedule page

Equipment

Three prototypes were created to test the key tools utilized in the three concepts. These prototypes are shown in Figure 24, 25 and 26. Further details about the prototypes and how they work are described in Appendix VI.

In addition to the prototypes, a notebook and pen were used for taking observations.

Procedure

The full procedure for each separate group is described in detail in Appendix VI.

Prior to the start of the testing, participants were divided in to three groups, with each group testing a different key tool.

Once seated, each group was given an explanation of the study and were instructed on how and when to alter between sitting and standing based on their tool.
This phase of the study lasted three hours,

during which the researcher conducted observations and tools notes on the participants actions.

During the course of the three hour period, brief discussions were held with each group to discuss their experience with using the tool as a means to alter between sitting and standing. During this discussion the following questions were asked:

How did you feel about using the tool (social support, task-based transitions, or body & mind cues) as a prompt to transition between sitting and standing?

How do you think a solution that utilized this tool would motivate you to standing up more while work in the future?

What do you think are limitations of using this tool as a prompt for adjusting between sitting and standing?

Data Analysis

During the study observations were recorded in a notebook and later transcribed into a word document. These notes are included in the appendices.

Additional data was collected using Google Forms and later transcribed using Miro. In Miro, data was first divided according to participant responses and then clustered according to patterns and similarities in responses. These responses were then divided into positive and negative opinions about the key tools.

Image Source: Photo by Michal Adar

Image Source: Photo by Michal Adar

Results

As seen in Figure 27, participants seemed to have a more positive experience when using social support and body and mind cues as a promt for altering their desk height over task-based transitions. There were various reasons behind this outcome and some of these factors presented below

Social Support

+ Positive effect on office environment and reducing the social barrier
+ Prompted interaction between coworkers
+ Doing it in a group was effecting
+ Colleagues were able to remind one another to make the transitions
+ Bonding experience
− Goals could become repetitive
− Limited autonomous decision to change position

Body & Mind Cues

+ Increased awareness of discomfort in body
+ Increased participants ability to listen to body
+ Positive reaction to tool that aimed to help user mentally scan body
+ Participants were able to based transitions based off how their bodies felt after only a few transitions
+ Light-as-a-reminder was a nice reminder (but need to be placed a certain way so they can been seen)
− Check-in moments broke concentration
− Slight psychological discomfort at altering position in the beginning (felt alone)
− Might force people into a position they don't like, might follow it blindly
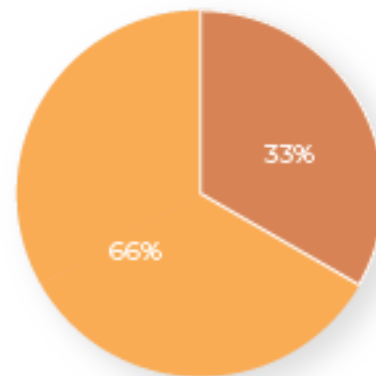
Task-Based Transitions

+ It gave a sense of consciousness about the postures
− Lack of autonomous decisions to transitions
− Participants stayed in a position longer than they thought was comfortable because it was not complete
− Participants felt like it added another task to their workday
− Long set-up

Would a product or service solution that utilizes the tool be able to motivate you to stand up more while working in the future?
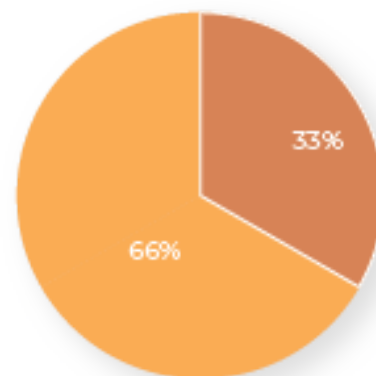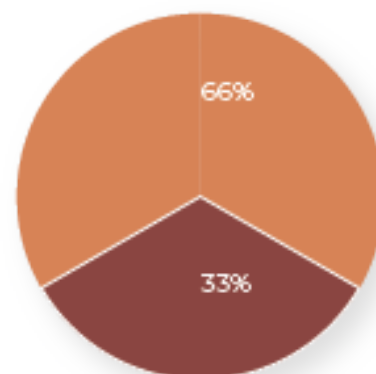
- Yes
- No
- Maybe

33%
66%

Social Support / Team Goal

33%
66%

Body & Mind Check-In

66%
33%

Task-Based Transitions

Figure 27: User evaluation o f the three keys tools and their ability to motivate sit-stand desk use in the future.

Desktop Coach	My Sit-Stand Lamp	Body & Mind Mouse
2.8 / 5.0	3.2 / 5.0	4.0 / 5.0

Interest in Using the Product - Average Ratings

3.6 / 5.0	3.1 / 5.0	4.3 / 5.0

Ability for the product to decrease sedentary behavior at the office - Average Ratings

Figure 28: User evaluations of desirability of the three products and their ability to reduce sedentary behavior at the workplace

Phase 2: Product Concept Evaluation

The second phase of the study consisted of an Online questionnaire in which participants were asked to evaluate and compare the three concepts against the pre-set requirements. Through this evaluation many key insights were gained and an itemized response method was used to determine the features that should or should not be included in the final solution.

Results

The main results from the online questionnaire are presented in Figures 28, 29, 30. As shown in this figures, participants often preferred the concept of the Body & Mind mouse and believed that this product would be the optimal prompt to decrease their sedentary behavior in the workplace. This was followed by the Desktop coach, as although participants were not as interested in the concept itself, they did often believe that social support, as long as it did not force a change, was a great tactic to motivate a decrease their sedentary nature. Participant responses were influenced by various factors. These responses were clustered and are summarized on the following page.

Desktop Coach

+ Peer support can inspire change
+ The coach is like a helpful friend and
+ reminder
− Doing it together often helps with motivation
− This could feel like being monitored
− This might reduce autonomous decision to change
− Increasing healthy habits is a personal thing
− Could be distracting from work
− Moving up levels might deter new users
− Goals could become repetitive
  Potential for loss of interest

Body and Mind Mouse

+ Increases awareness of body & mind
+ More customizable and allows for more freedom
+ Physical triggers/reminders are nice
+ Simple and Effective
+ Allows for autonomous transition (Users began to transition on their own)
− Potential to ignore the cue after a time
− Some people are sensitive for changes, so type of cue is important for consideration
− Not everyone uses a mouse or may forget it

My Sit-Stand Lamp

+ Light as a cue
+ Promotes time-management and productivity
+ Nice physical reminder
− Not everyone uses a lamp
− Dislike of other's managing time
− Too long of an initial set-up
− Too many color changes
− Could be distracting to work
− Dislike of having phone on desk

Itemized Response

All of the concepts evaluated received positive and negative feedback as well as ideas on how to alter the product so that it better suited the user's needs. Each of the responses were categorized and clustered using an itemized response method (Delft Design Guide) to show the pros and cons of each concept. Figure 30 presents the results of this analysis.

Based on all of the participant feedback, utilizing the body and mind as a prompt for altering position appeared to be the most effective and most desired method.
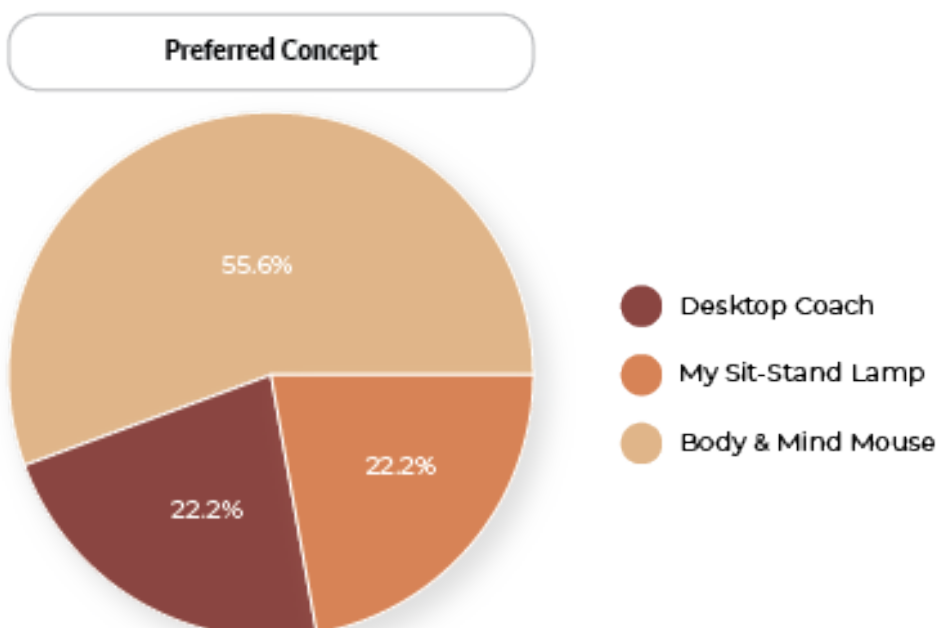

Figure 29: Participant preferred concept after evaluation.

	Desktop Coach	**My Sit-Stand Lamp**	**Body & Mind Mouse**
Concept			
Key Feature	Social Support & Challenges	Task-Based Transitions	Body & Mind Check-In
What Works	+ Reminders to alter position	+ Reminders to alter position	+ Easily integrated into the office desk
	+ Raising & lowering desks = bonding experience	+ Use of light as the reminder	+ Physical trigger / reminders
	+ Working together made it fun		+ Increased awareness of body
	+ Promotes interaction with colleagues		+ Focuses on the individual (personal) development
	+ Rated 3.6/5 in altering sedentary behavior at office		+ Autonomy to choose when to stand or sit
	+ Reduces social barrier in environment		+ Rated highest in interest & potential to reduce sedentary behavior
What Does Not Work	− Coach seems annoying	− Long initial set-up	− Not everyone uses a mouse
	− Only alter according to challenge, not based on own desire	− Too many color cues	− Check-in pop-ups are annoying if used too often
	− Not very personal	− Not everyone uses a lamp	− Potential loss of interest long term
	− Potential loss of interest long term	− Too much phone use	− Light was easy to ignore (out-of-sight, out-of-mind)
	− Lowest interest in use amoung participants	− Phone on desk = increased potential distraction	− People may only alter position when trigger goes off
	− Adds another product on the desk	− Only alter according to task, not by what body needs	− Quick light change affects may break work concentration
	− Goal may become repetative	− Rated low in interest & potential to reduce sedentary behavior	

Figure 30: Itemized response of the pros and cons of each concept.

Conclusion

As indicated in the user study, a person's body and mind are powerful resources for change and by simply improving upon their self-awareness, they can develop the ability to utilize cues from these resources as indications for when it is time to alter between the sitting and standing positions. This was noted by participants who tested the Body and Mind cues as they stated that after a few transitions, they became more conscious of how their bodies were feeling, and after a bit of time, they were able to transition between the two positions without the aid of the light reminder and check-in evaluation form. This autonomous transition was not noted with participants who were evaluating the alternative key tools: social support and task-based transitions. These participants felt as if they had less control over when to stand and had to follow the sit-stand times they had set at the beginning of the study. These factors continued to be relevant in the evaluation of the three concepts with participants preferring the Body and Mind Mouse over the other two concepts.

Although the Body and Mind Mouse appeared to be the most promising solution, various elements of the design should be improved upon. These features are based on user feedback and the pros of the other two concepts.

Features to include

— Physical reminder (not on computer or phone)
— Conditioning to increase awareness of mind and body (self-scans)
— Focusing on the individual (sit-stand transitions and personal development)
— Limit the time spent setting it up
— Maintaining a sense of autonomy
— Providing tips to improve positioning and posture
— Versatility because not everyone uses a mouse (or lamp)
— Provide option for Social support & working together to make it fun
— Optimal placement so trigger is not out-of-sight, out-of-mind
— Not annoying trigger to avoid breaking user concentration
— Maintaining long-term interest

Behavior Change

Although increasing physical and mental self-awareness is a first step in altering the working adult's sedentary behavior, sitting remains to be a habit, and altering this behavior requires continued maintenance and check-ins. Often when individuals are attempting to induce a behavior change they have relapses and slide back into their old routine. For this reason, the final solution shall consider the steps towards long-term behavior change and provide users with the tools they need to continue conducting their body and mind check-ins and using these as prompts for altering position.

"The final solution shall enable desk-based working adults to use their body and mind as cues for long-term behavior change, regarding their sedentary behavior, by providing them with feelings of control, competence, and social support while at their workplace."

Limitations of the Study

Due to the Covid Pandemic, there were restrictions on who could enter the IO faculty for testing. For this reason, nine master students from the IO faculty were used as test participants. These students do not fall into the target group of desk-based working adults, but due to the nature of their study and the fact they are accustomed to prolonged periods of desk-based work, they provided an optimal alternative to working adults.

A second limitation occurred due to the limited time available for testing. The test session occurred throughout the afternoon, 13:45 - 17:45. In the initial testing plan, participants would participate in the study over three full days and would be able to test out and evaluate each of the three key tools. This way, each day would provide users with enough time to evaluate the tools and determine how it would work for them. But due to the limited time, the participants were divided into three groups, each testing a different tool. At the end of the study, participants were then able to evaluate their tool and compare it to the three concepts. This short period limits the ability to do a long-term study on the key tools but did provide a lot of key insights.

09
CONCEPT DESIGN

Combing all of the knowledge and insights gained from the literature analysis, user research, and concept evaluation, the final concept is developed. The goal of the final concept is to stimulate desk-based working adults to alter their current behaviors and begin to utilize their sit-stand desks more often. This means that the final concept shall promote the working adult to make more transitions between sitting and standing while at their desks. Based on the feedback during the initial research phase, it became apparent that although many working adults who do have access to sit-stand desks want to alter their behavior, there are many perceived barriers and it is often a challenge to alter a current behavior.

The solution puts the working adult at the center of the design and utilizes their ability to tune into their bodies as a means to reduce their sedentary behavior. The results of the concept design phase present a well-founded concept that, with additional development, aims to reduce their sedentary behavior while at the office.

Contents

CONCEPT DEVELOPMENT

Designing for Behavior Change

It is a challenge to create a desired behavior within the workplace culture and the first step to do this requires the user to have the initial motivation to make the change. In chapter 05, *The Working Adult,* a brief analysis of behavior design and habit formation is done. According to the Hooks Model, in addition to motivation, there are four critical phases when forming a new habit: trigger, action, reward, and investment (Batterbee, 2020).

Based on the experiences and research done in the previous sections, subcomponents for the four critical phases are created. Working with subcomponents makes it easy to identify the areas which need to be designed in the final concept. Each component is described in the following sections.

Motivation

Motivation is key when it comes to promoting a change in behavior or a habit. Through the user research, the significant motivating factors were identified.

Motivation #1: Body & Mind Awareness

A person's body and mind are powerful tools for change and helping them become more aware of how they are feeling proved to be a popular method for motivating users to alter between sitting and standing.

- Help users take a moment to be mindful
- Provide users with a step-by-step check-in tool

- Provide users with progress tracking to help them understand how their change in position affects their physical and mental state.

Motivation #2: Social Support

There were mixed reviews about the use of social support to motivate users to transition between sitting and standing. Some participants really like the idea while others wanted to keep it more personal.

For individuals who are more resistant to altering their sedentary behavior at the workplace, a more gradual trigger may be necessary. In the initial user interviews, one of the key elements that motivated users to pick up the sit-stand habit was seeing their coworkers or supervisors doing it.

- Option to participant in social groups to promote activity (eg. competitions, team-based challenges)
- Seeing coworkers use sit-stand desks acts as a motivator (we typically want to fit in with those around us)

Motivation #3: Education

Many participants were unaware of the adverse effects that their sedentary behavior can have on their body's nor did they associate the pains or discomfort they had been feeling to this.

- Articles about the impacts of sedentary behavior
- Personalized tips on how to improve posture and reduce discomfort

Trigger

The trigger is the thing that the user senses in their world which they can learn to associate with an action. For the final solution there different types of triggers, each of which has a significant role in promoting the user's motivation to develop the habit.

Trigger #1: Body & Mind Cues

One of the key triggers that enabled participants in the first user interviews and in the idea evaluation, was their ability to become more conscious of their physical and mental state and use these cues of discomfort as indications to change position.

- Enable users to be able to use their body & mind as cues for transitioning
- Provide users with moments to be mindful/ micro break from work

Trigger #2: Physical Reminder

Working-adults are very busy while at the office and often are so focused they become less conscious of how they are feeling and forget to alter between the sitting and standing positions. For this reason, several participants mentioned the need for some sort of reminder which can help them to remember to check-in on themselves to notice how they are doing. During both the user interviews and idea evaluation it was noted that:

- Physical reminders are often preferred over digital reminders.
- Light, vibration, sound
- Gradual trigger fade-in to reduce concentration break
- The trigger component should be optimally placed so that it is not out-of-sight, out-of-mind.
- Could help user take a second to look away from their computers

Action

The action is the key behavior that users want to perform. To ensure that the action can be taken, a key question is asked: how can the product be simplified to make this action easier?

Action #1: Time

Working-adults expect that the final solution should not take too much time to set-up or use as they have busy schedules and cannot afford to lose time from their workdays. During the idea evaluations it was considered that:

- The self-check in tool should not open every time the trigger goes off
- The initial set-up should be simple
  The product should automatically update as the user continue to form the habit
- The users should be able to "snooze" the trigger in case they are too busy (even by physically "snoozing," the user is required to take a second to themselves)
- Limit phone use (causes additional distractions)

Action #2: Effort

According to the behavior design, people are lazy and if a product requires too much effort than people are less likely to use it. The participants indicated that this is true and desired a solution that would not require too much thought process or physical effort to use.

- The user interaction with the solution should remain simple
- The solution should be within reach of the user (clip to computer, stand on desk, etc.)
- Simple button system for interaction
- Use automation to track sit-stand transitions
- Use automation to set goals based on user progress

Action #3: Control

One of the key factors of motivation is that the user should always have a sense of autonomy over their action.

- The user should always feel in control
- The user should be able to decide whether they alter between sitting and standing
- The user should be able to decide when they want to check-in on how they are feeling.

Variable Reward

The aim of the variable reward is users end up feeling fulfilled and are left wanting more. For this solution there are two types of rewards.

Reward #1: Internal

When testing the body & mind mouse idea, users felt that the reduction in physical discomfort was a great initial reward that encouraged them to want to transition between sitting and standing. However, there was concern that this may not be enough to help them maintain the habit long -term.

- Help users become aware of the positive benefits transitioning position has on the body and mind
- Progress tracking to should the effects and development over time

Reward #2: External

A second source of variable awards could aid provide working adults with the feeling that they are becoming more competent by achieve their goals.

- Preset goals
- Rewards (badges) based on user feedback /progress
- Variable reward to keep user engaged Workplace discounts (established by the company)
- Leader boards for competitions or team-based challenges

Investment

The Investment is the time, effort, and personal information users contribute to the product to improve the overall experience. This brings value to the final solution and aims to keep users engaged.

Investment #1: Personalized Experience

Participants were asked what kind of elements they would want to remain engaged with the final product. Their answers included the following:

- Personalized to own work schedule
- Automated goals based on previous progress

Development Phase 1: Simplifying the Interaction

Although designing a solution to induce a specific behavior is complicated, the interaction between the user and the final product should be kept as simple as possible to ensure the most optimal outcome. For this reason, a decision is made to design a digital application & physical product combination.

In this solution, the user's main interaction would be with the physical product, or controller, which provides them with the trigger and allows them to decide whether they are ready to accept it and "check-in" on how they are feeling. The controller should also contain a component to automatically measure the user's sit-stand transitions.

As the user interacts with the controller, the data they input, as well as the automatic sit-stand measurements, will be sent to a digital application. The digital application will store all of the information and provide the user with motivational support, education on sit-stand desk benefits, and variable rewards. In this solution, the user can choose how much time and effort they want to put into the digital application, but the overall main interaction should require minimal effort.

Development Phase 2: Selecting the Technology

Before establishing the final concept design, there are several areas of the product that need to be specified. To do this, a simple morphological chart (Figure 31) is used to develop three technology set-ups followed by a rapid prototyping and testing session. Each tech set-up was evaluated using the Harris Profile Chart described in the Delft Design Guide. The Arduino code, test set-up, and evaluation are detailed in Appendix VIII. The final technology combinations are created to test the following:

Type of Trigger (Output)
What is the best type of physical reminder to indicate to the user when it is time to do a self-check-in? Although using light as the trigger/the physical reminder a was popular option during the user testing, it is important to test it against sound and touch triggers to ensure that it provides the optimal solution.

Type of User Controller (Input Interaction)
A touch sensor, button, and rotating dial were all tested to determine which provided the best interaction for the user when selecting to interact with the product and turn off the trigger/reminder.

Product Attachment & Desk Placement
As one of the key components was the need to create a product that is versatile, accessible, easy to reach, and always in-sight, different attachment/placement styles were tested. This was based on a brainstorming session and evaluation of what working adults typically have on or around their desks (see Appendix VII).

Method

A self-testing session was held over four days with one tech combination tested per day. The prototypes were tested in both the home office and in an open office space. Notes were taken concerning the experience with each prototype.

Prototypes

Each prototype was developed using the Arduino IDE Application, an Arduino Uno Board, the relevant components, and materials around the house to create the different attachment styles. The Equipment used for each prototype is described in Appendix VIII and Figure 31.

Evaluation

At the end of the study, the four technology combinations were each evaluated based on the following requirements:
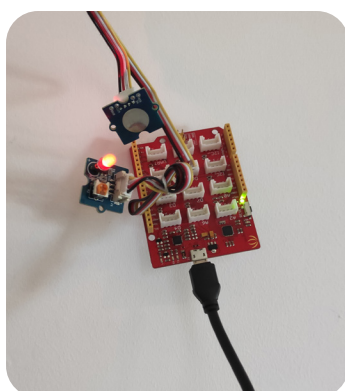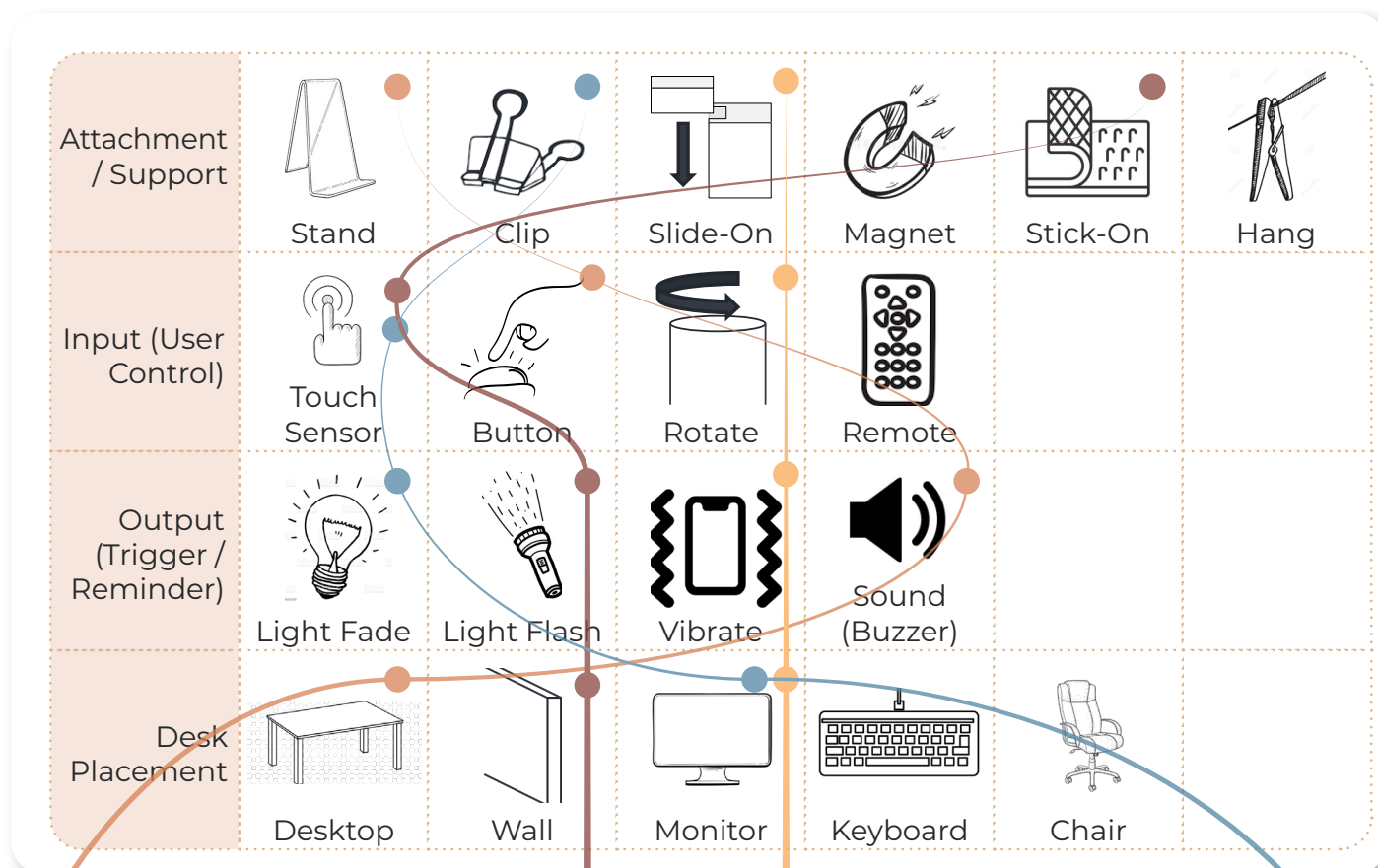
1. Not Distracting to Self
2. Not Distracting to Others
3. The user is in control
4. Ability to act as a reminder
5. Easily Integrated into the workspace
6. Compatible with a sit-stand desk
7. Easy-to-use

Results

As seen in the Harris Profile included in Appendix VIII, Tech Set-up 4 proved to be the optimal solution out of the four technology combinations for the following reasons:

— The gradual change in color was not distracting to work
— Felt comfortable using this in the office with coworkers as there were no loud sounds or motions to distract them
— The light could be noticed when the user was ready
— The clip can be adjusted to different widths to account for different objects on the desk
— If placed on the monitor it is easily reachable
— Touch sensor provided a quick and effortless way to shut the light off
— It was easy to use
— Possibility to also adjust the clip so it can work as a stand (in case the user wants to place it on their desk)
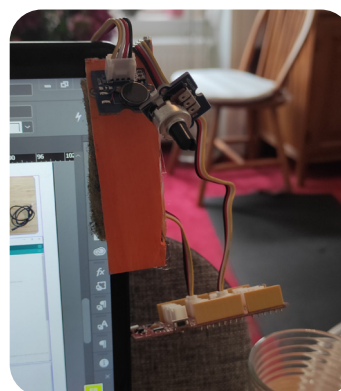
The only downfall of the solution was that it could be easily ignored and if the clip is wider, it could impact the monitor screen visibility.

Attachment / Support	Stand	Clip	Slide-On	Magnet	Stick-On	Hang
Input (User Control)	Touch Sensor	Button	Rotate	Remote		
Output (Trigger / Reminder)	Light Fade	Light Flash	Vibrate	Sound (Buzzer)		
Desk Placement	Desktop	Wall	Monitor	Keyboard	Chair	

Tech Set-Up 1

Equipment:

Tape
Grove Touch Sensor
Grove Red RGB LED
Wall

Tech Set-Up 3

Equipment:

Slide on (cardboard & foam)
Grove Angle Sensor
Grove Vibration Motor
Monitor
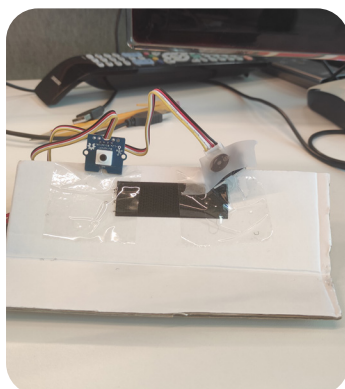
Tech Set-Up 2

Equipment:

Stand (Cardboard & tape)
Grove Button
Grove Buzzer
Desktop

Tech Set-Up 4

Equipment:

Clip
Grove-RGB
Chainable LEd
Gove Touch Sensor
Monitor

Figure 31: A morphological chart and it technology set-up outcomes.

Development Phase 3: Specifying the Components

Connection

The controller and digital application will be connected through a network so that data can be transferred between the two. Today, a vast majority of devices have wireless connections, and many different frequencies and protocols are used to communicate. Often, large companies use more than one of these technologies to function, and the wide range of connectivity methods allows for increasing compatibility opportunities. The table in Appendix IX provides an overview and evaluation of the different connection methods (Morales, Lopez, Parado & Pasaoa, 2016; "Designing better-connected devices", 2016). As the desired product will remain in relatively close range to the user's computer, Bluetooth Low Energy presents a viable solution for the product connection as it has low energy consumption and is relatively cheap.

Charging

For the product to function, it requires an energy source and form of charging. It is important to select the charging method in the early stages of the concept development as it will determine the necessary inner components and aspects of the design specifications. There are three main forms of charging methods currently used in many products today: wired, wireless, and batteries. These three methods are evaluated in Appendix IX. For the final solution, a wired charging method is selected as it is more versatile and generally requires less space than a wireless charger.

Automatic Sit-Stand Transition Tracking

To make the interaction between the user and the solution as simple as possible, one idea is to automatically record and track the user's transitions between sitting and standing. To do this, the product will require some sort of sensor capable of measuring the change in height of the desk. For this project, a two-way infrared LED sensor will be used. Infrared sensors work on the principle of reflected light waves. The infrared light is reflected from objects and is used to measure distance or proximity. The reflected light is detected and then an estimate of distance is calculated between sensor and object (Burnett, 2017).
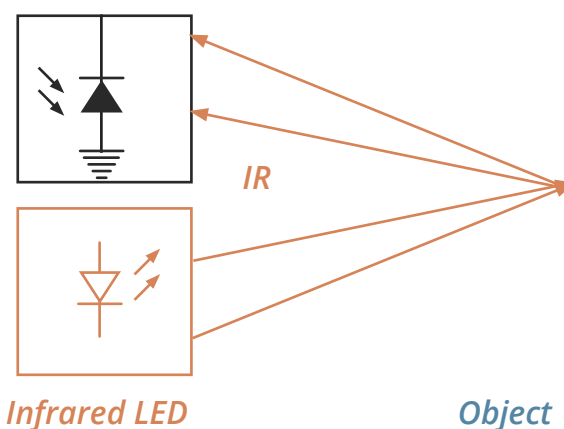

Figure 32: How Infrared (IR) Sensors Work

Touch Sensing

Like many smart products used today, the final product will incorporate a touch sensor that will allow the user to "check-in" or "snooze" the application. Various methods allow for touch capability. For the prototype, an Arduino touch sensor will be used. This touch sensor works like a switch, where when there is contact or pressure on the surface of the sensor, it opens up an electrical circuit and allows currents to flow through it and can remain in this position until another pressure is applied
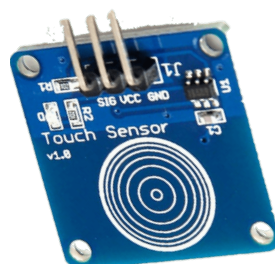

Image Source: CircuitUncle

Light

The product will incorporate a light as the cue for checking in. Several types of light bulbs can be used and the final selection must include a bulb that is energy efficient and capable of dimming on and off. For these reasons, as well as cost and bulb life, LEDs are selected for the final product as they are the most durable and energy-efficient (Williams, 2017). An evaluation of different types of light bulbs can be found in Appendix IX.

Indirect Lighting

Ambient light is light that substitutes for natural like. It consists of an indirect lighting method that improves the sense of warmth and provides a comfortable level of illumination without too much glare (Brooke, 2019). The light can be used to create specific atmospheres or make a product/environment look more relaxed. By incorporating simple ambient lighting, the goal is to reduce the glare users experience when the cue goes off while also connecting the product with a peaceful physical and mental check-in experience.

Controller Dimensions

One of the requirements of the final design is that it must be easily integrated into the workspace. Part of this means that it should be easily attached to the computer without affecting the workflow. A typical monitor screen size ranges from 48 to 86 cm diagonally with the average user often selecting a 55 - 61 cm screen (P, 2020). The screen is surrounded by a bezel and a frame which often has a width of about 8 - 9mm. To ensure that the product does not impact the user's workflow, the product attachment (clip) shall only cover the width of the frame and the bezel while avoiding being placed over the screen. Appendix IX shows an analysis of the dimensions compared to different monitor sizes. Figure 33 presents the final dimensions that the controller shall consist of. These dimensions are based on personal preference of product size ratio to screen size.
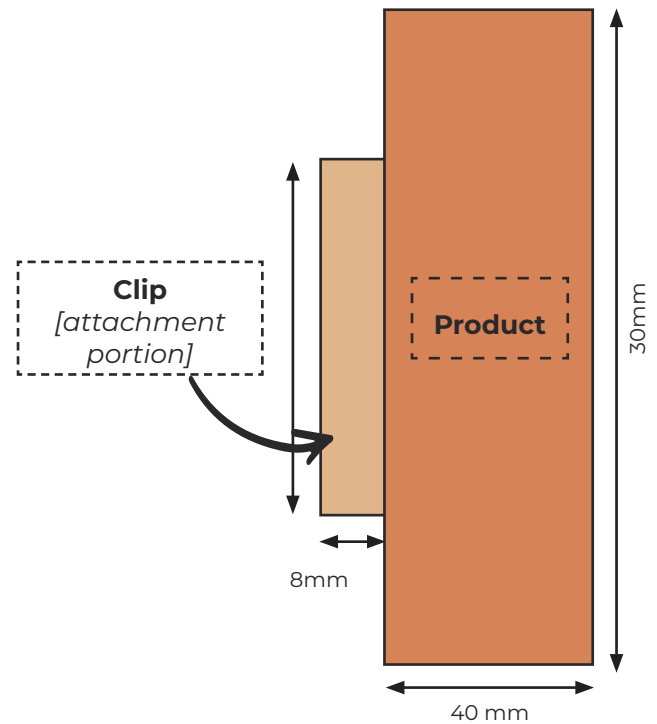

Figure 32: Controller Dimensions

Attachment (Clip)

During the testing of the user technology combinations in Concept Development Phase 1, different types of supports/attachments were analyzed. Based on these outcomes, a clip-on attachment style was selected. The size of the clip depends on both the motor bezel size as well as the monitor thickness as the clip needs to be versatile and able to attach to monitors of different thicknesses, the desk, or be able to stand on the desk.

The clip is designed to be attached to the right side of the screen. This is meant to account for 90% of people who are right-handed.
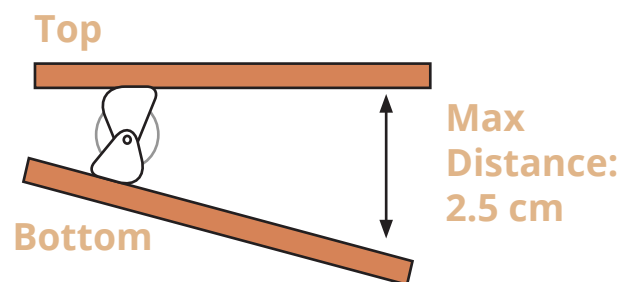

Figure 33: Clip max distance.

Development Phase 4: Form and Experience

The goal of the BMDesk is to enable working adults to develop a sense of mindfulness while at work by becoming more in tune with their physical and mental state to realize when it is time to transition the height of their desks. To promote this feeling, the product aesthetics and interaction qualities play a crucial role in how the user experiences the product. To promote a sense of mindfulness, a brief form-driven design method was used to present a **simple** and **peaceful** product image while keeping in tune with the **elegant** nature of the workspace. A form-driven design involves three stages: sampling, sensory analysis, and manifestation. These three stages are presented in Figure X. For a closer look at the images, see Appendix X.

The final stage of the form-driven design process is the selection of the final controller design. This final selection was based on the designer's personal preference and is presented in the next section, *The Final Concept*.

Light Integration

One of the main functions of the controller is its ability to use light as a prompt for checking in on oneself. This light should provide users with a peaceful experience without distracting them from their work or glaring into their eyes. For this reason, the controller should be designed with an indirect lighting experience where the light is directed onto the product itself rather than at the user.
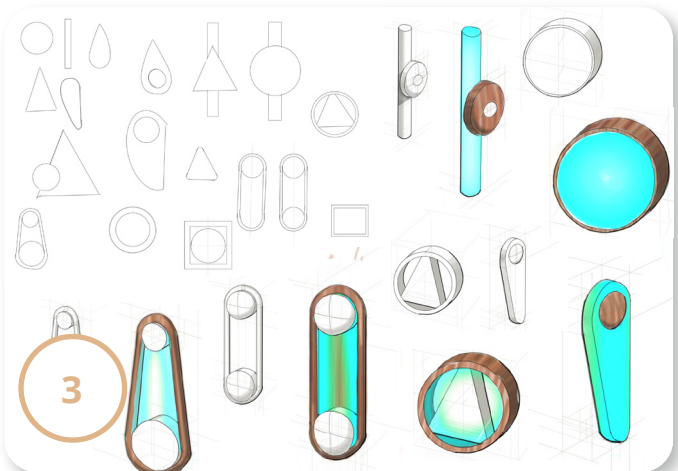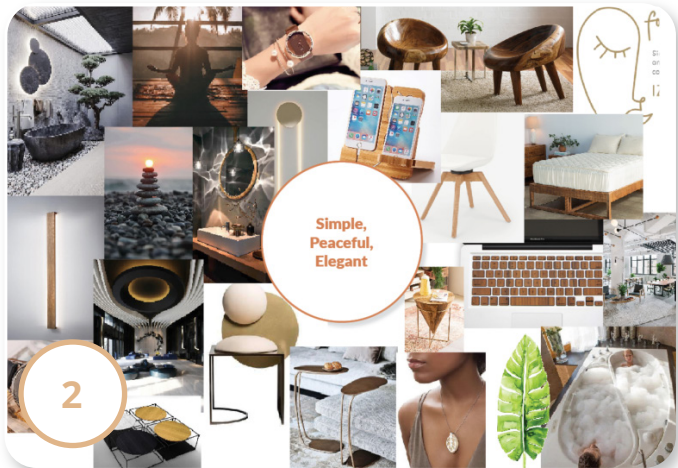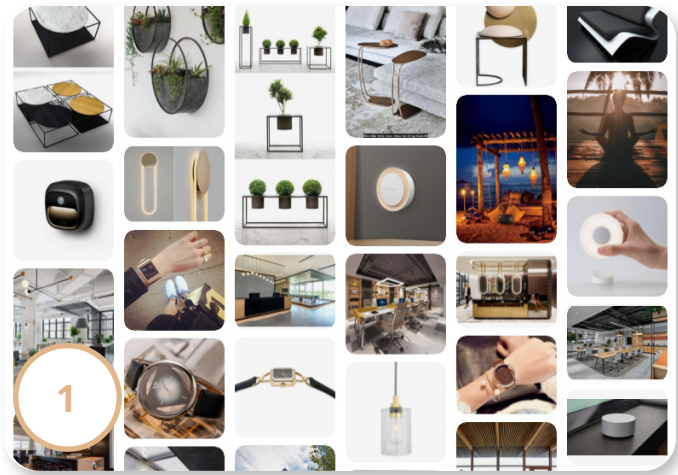

Simple, Peaceful, Elegant

Figure 34: (1) Sampling was done using Pintrest and Google Images. (2) Next, a mood board was created and used for sensory analysis and inspiration for the sketches. (3) The sketches were created on Sketchbook Pro. (4) Comparing the different designs.

THE FINAL DESIGN

Based on the elements described in the previous pages, iterations on the Body and Mind Mouse concept were done and the BMDesk Application and Controller is designed. BMDesk is a product system that is designed to assist working adults in becoming more self-aware of their physical and mental state and use their own body and mind cues as indications for altering their posture. The final product consists of a digital application that can be used on a smartphone or computer and a controller with which the user interacts.

Introducing the BMDesk Application & Controller

The BMDesk presents a solution that combines a digital application with a controller to aid working adults in using their own body and mind as indicators for transitioning between sitting and standing while in the workplace. The product consists of a controller that can be attached to the user's monitor and uses light as a cue to prompt the user to check in on themselves. Once the light goes off, the user can choose whether to check-in or snooze by pressing the correct button. When the user chooses to check-in, the digital app will open up on their screen to provide step-by-step directions for a body and mind scan. The user is then provided with tips on how to adjust their posture or make a transition between sitting or standing, based on their self-evaluation. If the user decides to transition their position from sitting to standing, or vice versa, the controller will note the change and automatically send it to the app where it will be recorded so that the user can track their progress. The BMDesk is further detailed and described in the following sections.
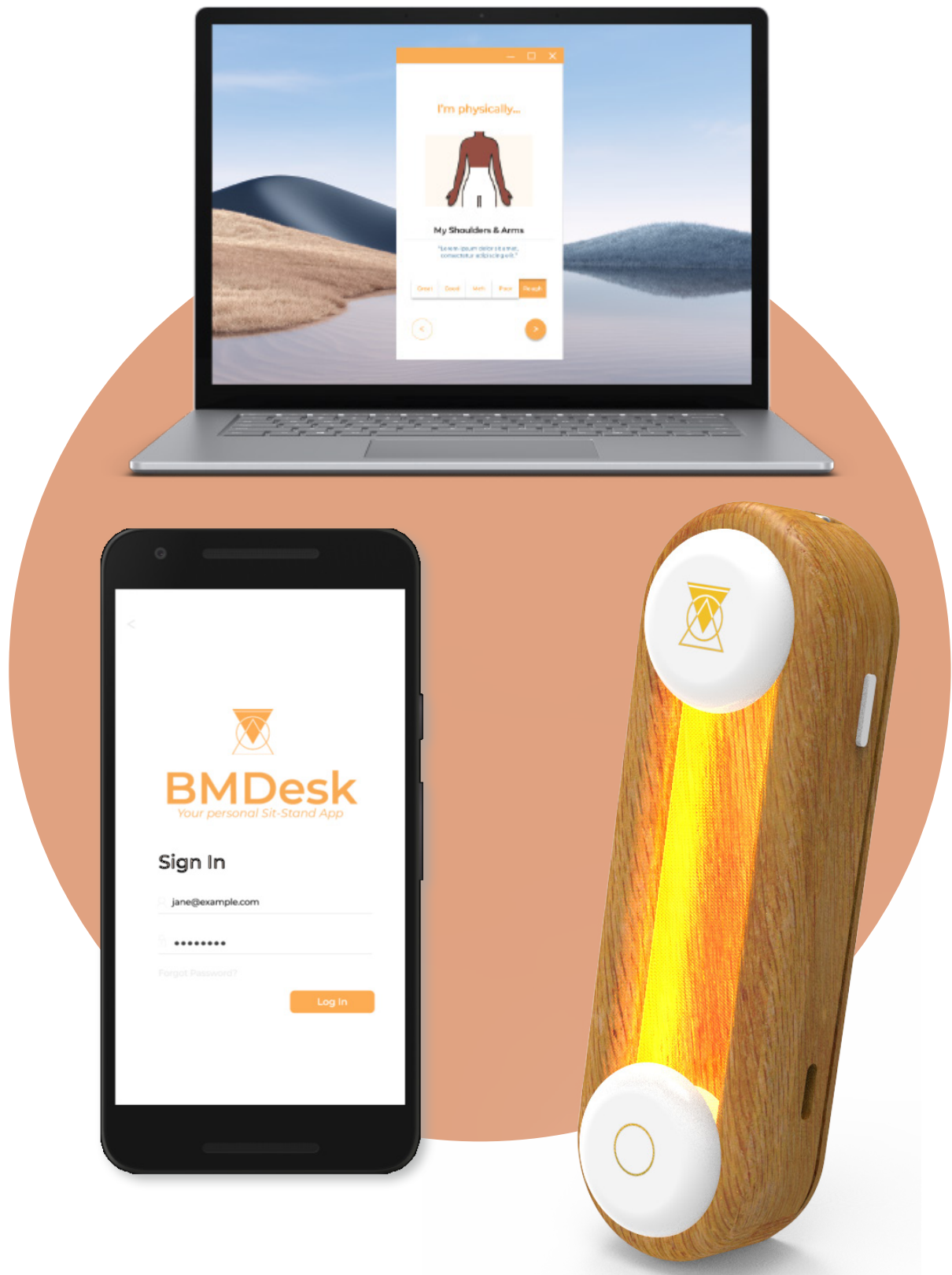
The Body -Mind Desk
App & Controller

Start the workday.
Julia arrives at the office at 8:00AM, turns on her BMDesk Controller, and begins to work.

Automatic Sit-Stand Tracking.
After 2 hours the BMDesk Controller notices that Julia has not altered her position and has remained seated.

Self Body & Mind Scan Tool.
The BMDesk Digital Application opens up and prompts Julia to do a Body & Mind scan to see how she is feeling both physically and mentally.

Indicate Areas of Discomfort.
As Julia is doing the self-scan she realizes that she is feeling discomfort in her lower back so the indicates it in the app.

Use Scenario

The BMDesk app and controller are designed to assist users in becoming more aware of their mental and physical state and use their body and mind as cues for altering their position throughout the workday. The product aims to motivate a behavior change and habit formation among working adults and does this by utilizing elements that promote the three basic psychological needs: autonomy, competence, and relatedness as well as the four critical phases of the Hook Model: Trigger, Action, Variable Reward, Investment. The following scenario and storyboard describe how the target group should use the BMDesk solution to decrease their sedentary behavior in the workplace.
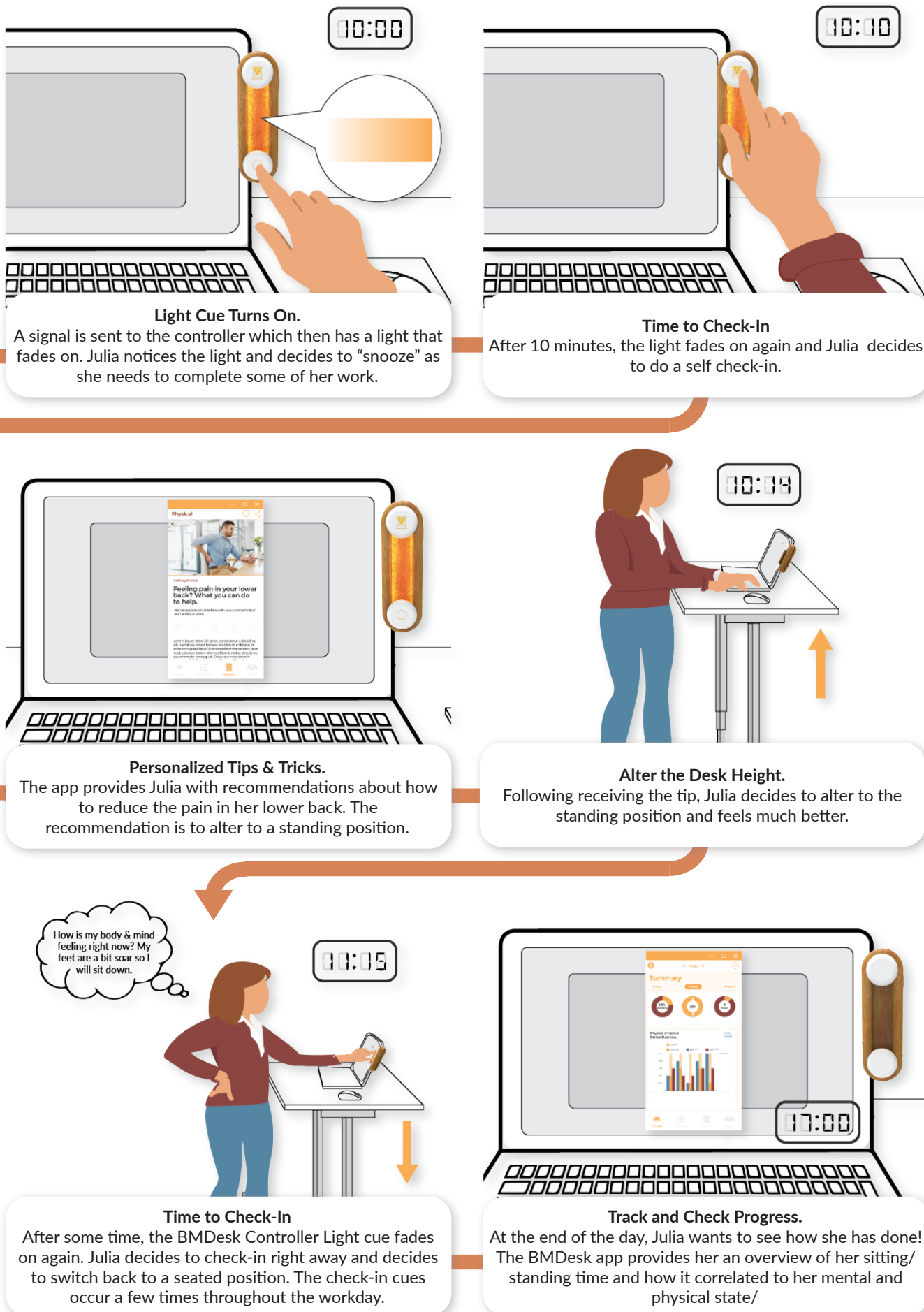
Light Cue Turns On.
A signal is sent to the controller which then has a light that fades on. Julia notices the light and decides to "snooze" as she needs to complete some of her work.

Time to Check-In
After 10 minutes, the light fades on again and Julia decides to do a self check-in.

Personalized Tips & Tricks.
The app provides Julia with recommendations about how to reduce the pain in her lower back. The recommendation is to alter to a standing position.

Alter the Desk Height.
Following receiving the tip, Julia decides to alter to the standing position and feels much better.

Time to Check-In
After some time, the BMDesk Controller Light cue fades on again. Julia decides to check-in right away and decides to switch back to a seated position. The check-in cues occur a few times throughout the workday.

Track and Check Progress.
At the end of the day, Julia wants to see how she has done! The BMDesk app provides her an overview of her sitting/ standing time and how it correlated to her mental and physical state/

Figure 35: The BMDesk Application & Controller Use Scenario Storyboard

THE
DIGITAL PLATFORM

Working adults tend to have very busy lives and desire the ability to remain focused and productive while at work. During the user studies, many participants indicated that they would prefer a solution that did not require them to look at their phones throughout the workday, as this may lead them to become distracted for a prolonged period. For this reason, and the desire to provide a solution that is flexible and can be adjusted to the user's needs, a digital application is designed that can be employed on either a smartphone or computer. With this digital platform, users can set up the system, input how their body and mind are feeling, receive tips on how to improve their sit-stand practices, team up with coworkers, and reflect on their progress with automatic tracking of their changing desk height. The digital application will be connected to the controller via Zigbee to provide light cues for when it is time to check-in and record the user's input and desk change. The following sections further describe the user journey with the digital application.
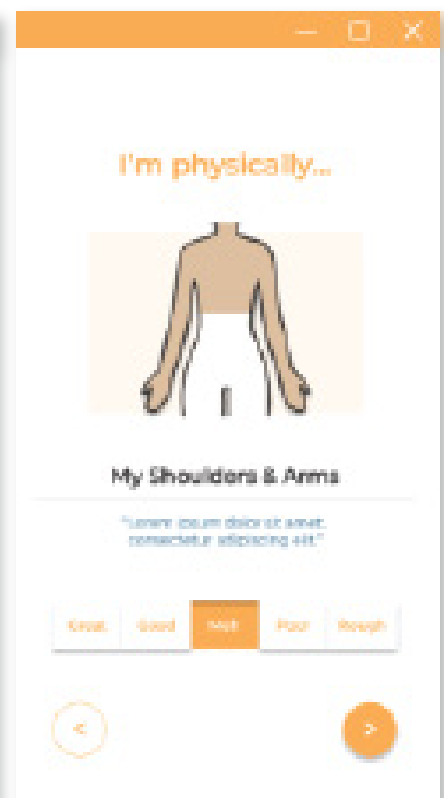
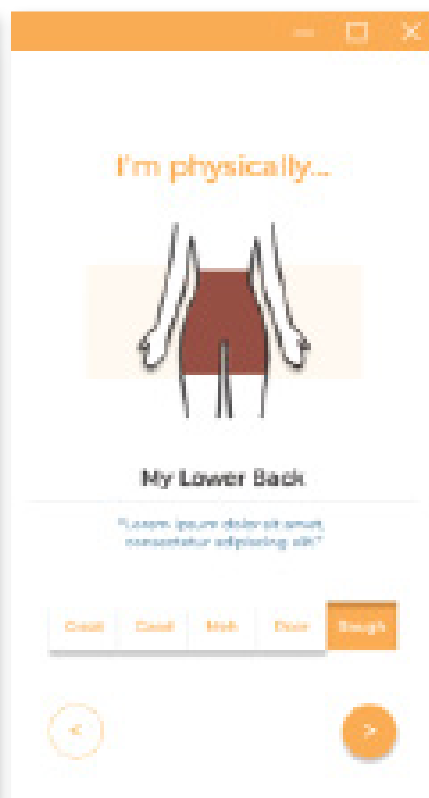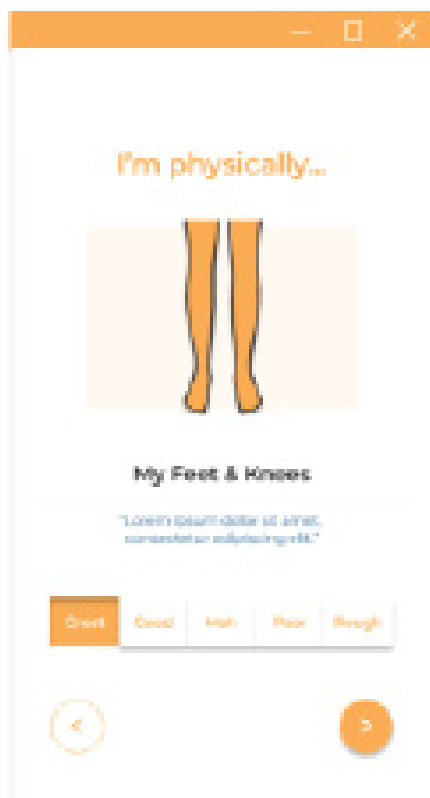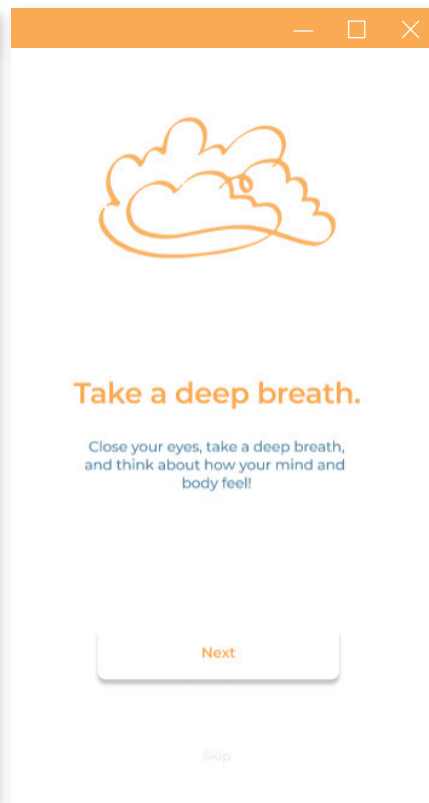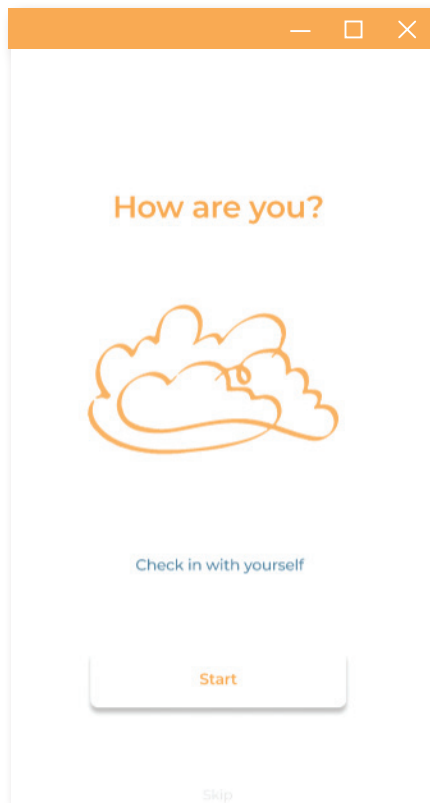*Test out the digital prototype by clicking or scanning the QR Code!*
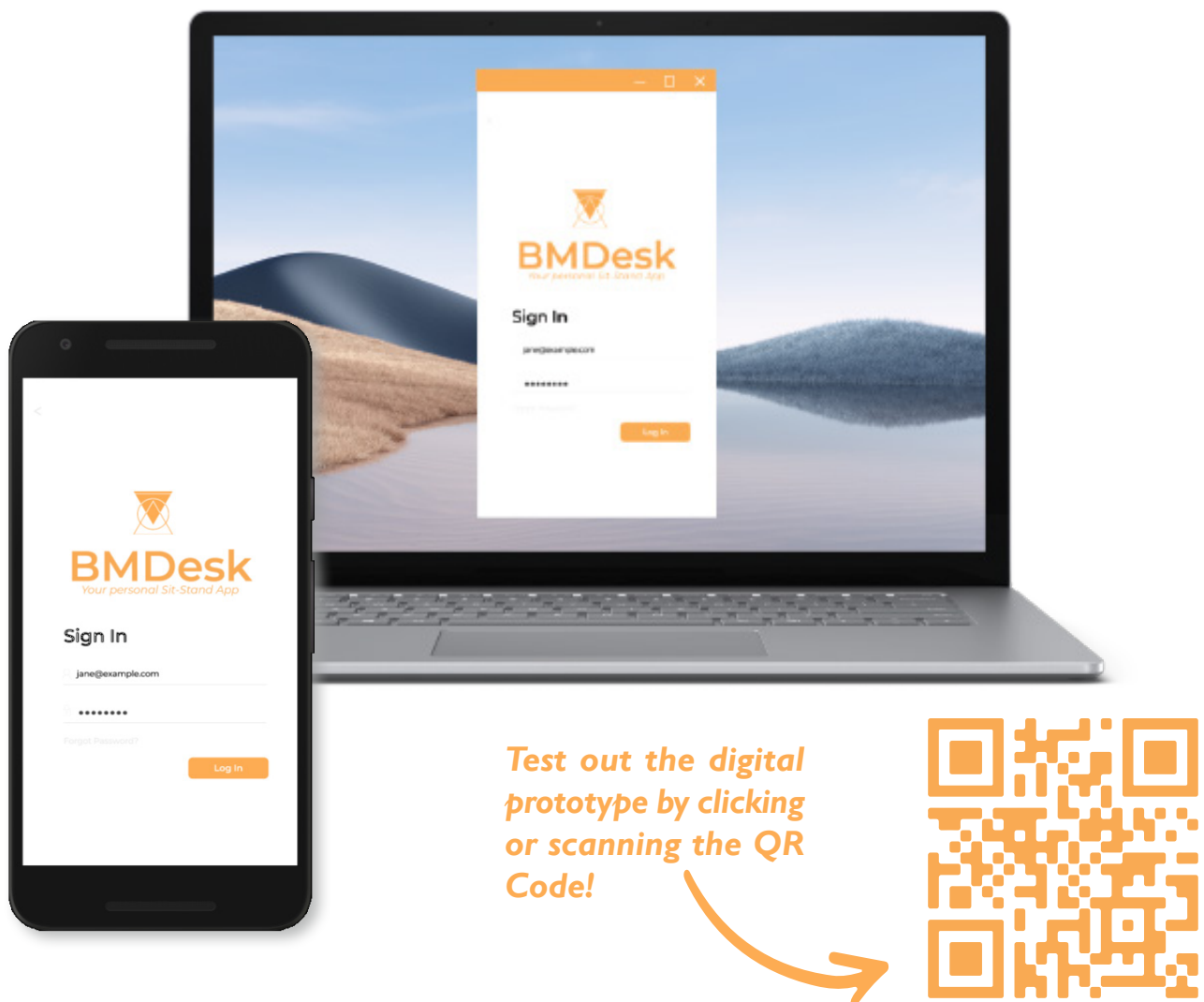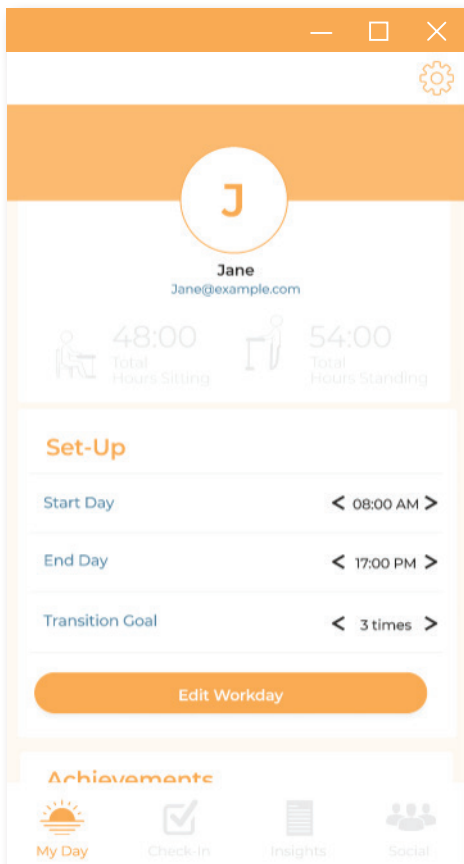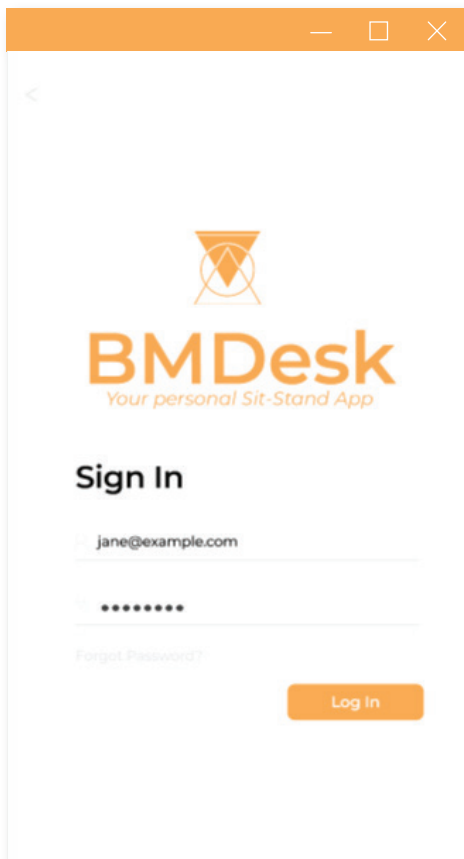
Set-Up Workday and Define Goals

The user will start by building their profile in which they will be able to set their workday start and end time and indicate how often they would like to check-in or make the sit-stand transition. This set-up will only occur once when the user first begins using the application. The app will then provide recommendations on how often the user should transition their desk height and how long they should stay in each position. These numbers will automatically adjust over time as the user begins to make the transition between sitting and standing more easily.

The user will also be able to select the color, or combination of colors, that they would like to use as their prompt for checking-in. Once the user's profile is fully set up, it will be automatically connected to the controller, and the process will begin. Based on the user's input, the controller will receive input from the app to indicate when it is time for the light-as-a-cue to turn on.

How are you?

Check in with yourself

Start

Take a deep breath.

Close your eyes, take a deep breath,
and think about how your mind and
body feel!

Next

I'm physically...

My Feet & Knees

"Lorem ipsum dolor sit amet,
consectetur adipiscing elit."

Great Good Meh Poor Rough

I'm physically...

My Lower Back

"Lorem ipsum dolor sit amet,
consectetur adipiscing elit."

Great Good Meh Poor Rough

I'm physically...

My Shoulders & Arms

"Lorem ipsum dolor sit amet,
consectetur adipiscing elit."

Great Good Meh Poor Rough

Check-In Tool: Body & Mind Self Scan

Following the user's input, the light-as-cue will turn on throughout the day indicating to the user when it is time to do a body and mind check-in. Once the user touches the "check-in" button on the controller, the digital app will open on their computer to provide them with the step-by-step body and mind check-in tool. This tool asks the user to start at their feet and knees and indicates how they are feeling physically in these areas on a scale of Great to Rough. This process will continue up through the lower back, shoulders, and arms, and to their head where they will be asked to evaluate their mood, energy, and focus levels. This body scan is based on meditation mindfulness practices meant to help the user tune in to their body and reconnect with their physical self.

The check-in tool will not pop up every time that the light turns on and the user presses the check-in button on the controller. It will be randomized and limited to ensure that

the user can continue to focus on their work as much as possible, but with a sense of consciousness about their choice of position. As the user becomes more adept at checking in on their mental and physical state and can change the height of their desks based on this indication, the light-as-a-cue will continue to turn on but the check-in pop-ups will occur less often. The goal of this is that the light acts as a reminder and the user automatically does a self-body and mind scan without the need for the aid of the check-in tool. In the case that the user regresses to their sedentary behavior, or often remains in a static position for too much time, the check-in pop-ups will increase to ensure that the user is able to remain conscious of how they are feeling.
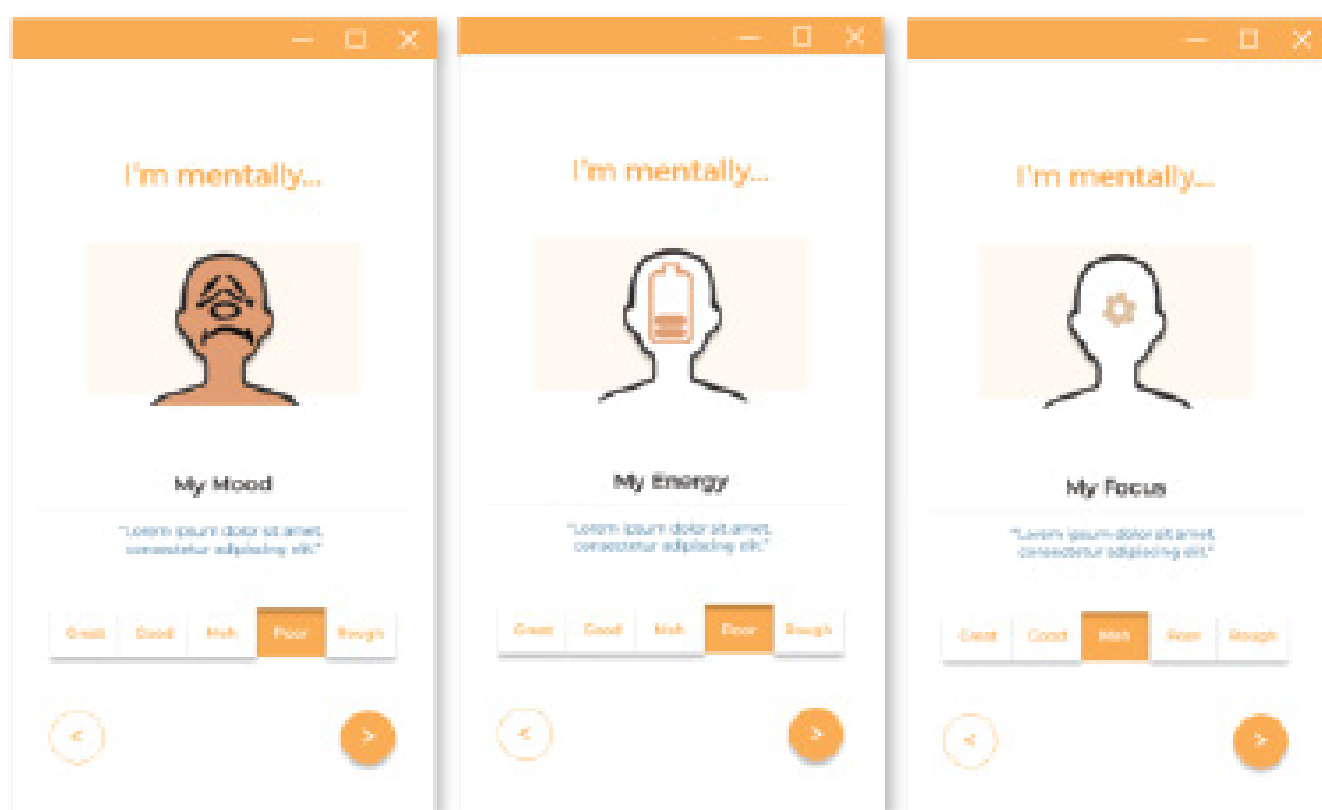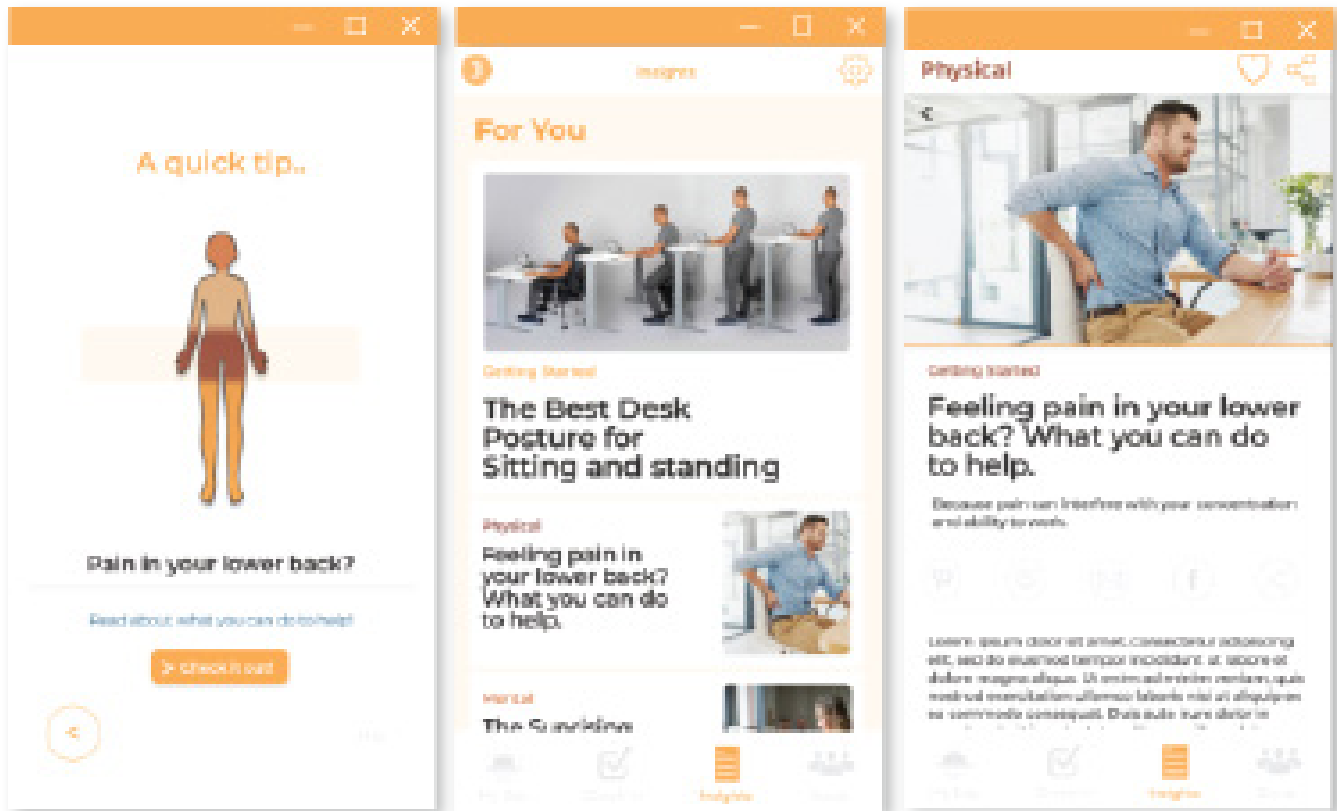
Receive Tips & Tricks

After the user completes their body and mind check-in on the app, the app will analyze the data and provide the user with a quick tip concerning how to improve upon the areas that they rank low. The user will also be provided with a link to an article in the case that they want to learn more. This article will be one of many that the user can read to learn about improving their mental and physical state while at the office and getting the most out of their sit-stand desks. By learning more about how to feel better and do better at work, the user will gain competence and will develop a better understanding of how to optimize their sit-stand experience.

Team-up With Coworkers

Changing a behavior can be difficult, particularly if a user is alone in the practice. BMDesk aims to bring coworkers together so that they can work together towards their common goal of reducing their sedentary behavior. By joining a group, the user will be introduced into a social network where coworkers support one another and can set specific challenges, or times to stand, related to the group. One example of this is the "Stand-up Meeting" group. This group consists of users who want to try to stand up during their meetings. The group page will provide a space where users can communicate with each other to share their progress, give support, and ask for advice. Users are also able to add their coworkers as friends and share messages privately.
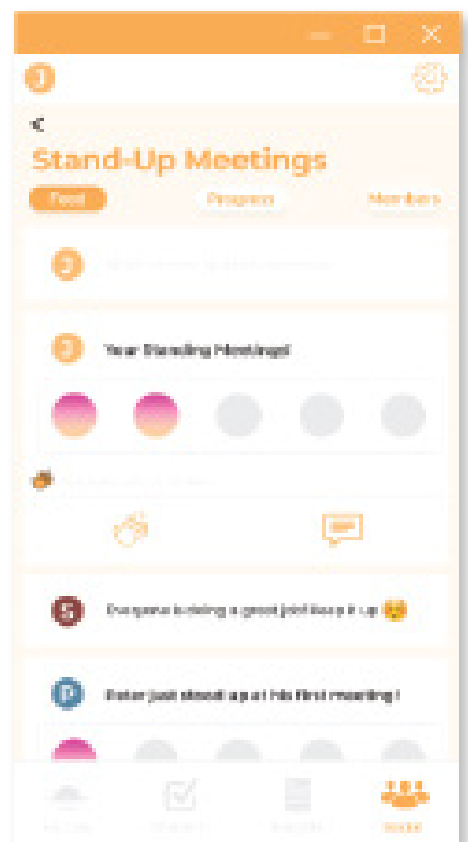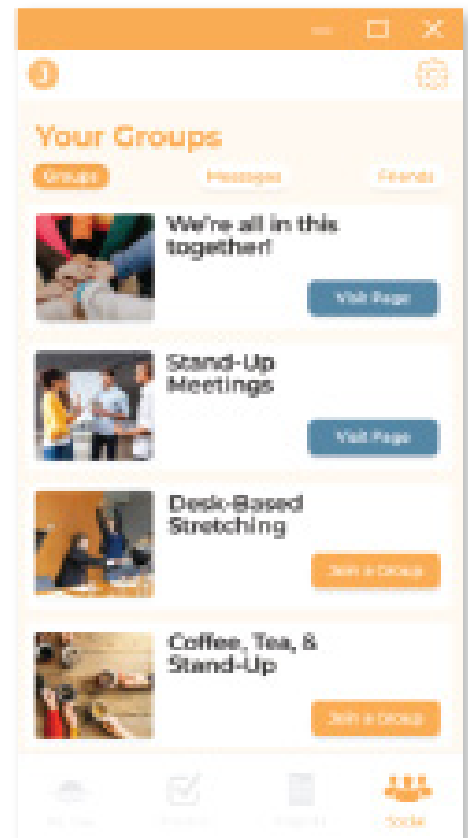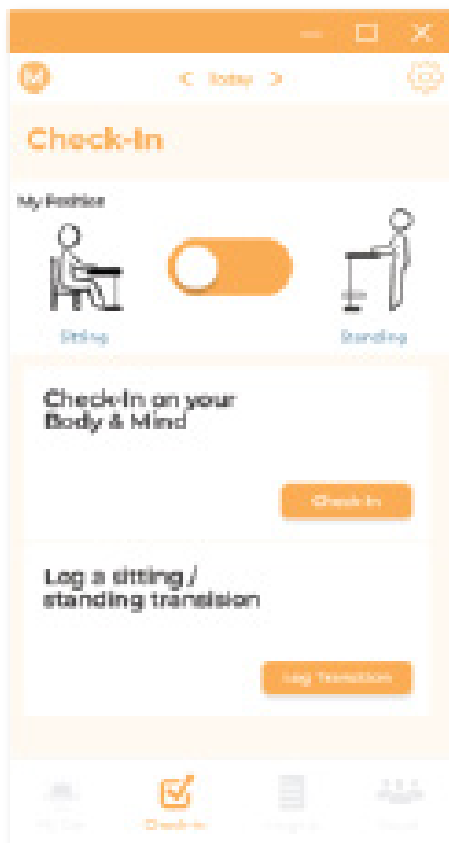
Reflect on Progress

Through data sent from the controller, the BMDesk will automatically track and record the sit-stand transitions the user makes as well as their inputs when checking in on their body and mind. The user will be able to track their progress throughout the day and see how their mental and physical state is affected by their transitions between sitting and standing. After a certain amount of time, the app will be able to analyze the long term data and adjust the check-in and light cue to go off when the user seems to need it the most (e.g. if there is a period in the day when they are often not feeling as great or are more sedentary). Gathering this data will help users to quantify their sit-stand activity and determine whether or not they are reaching their preset goals.

In the case that the user does not have access to the controller, they are also able to manually log their sit-stand transitions and body & mind check-ins.
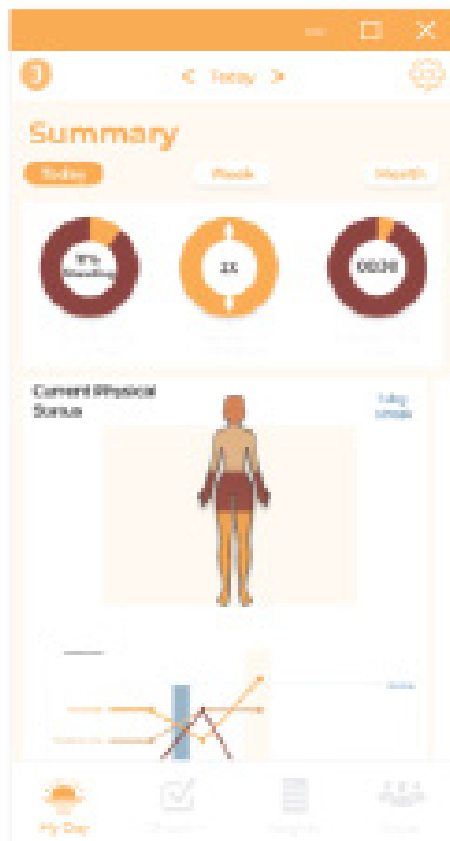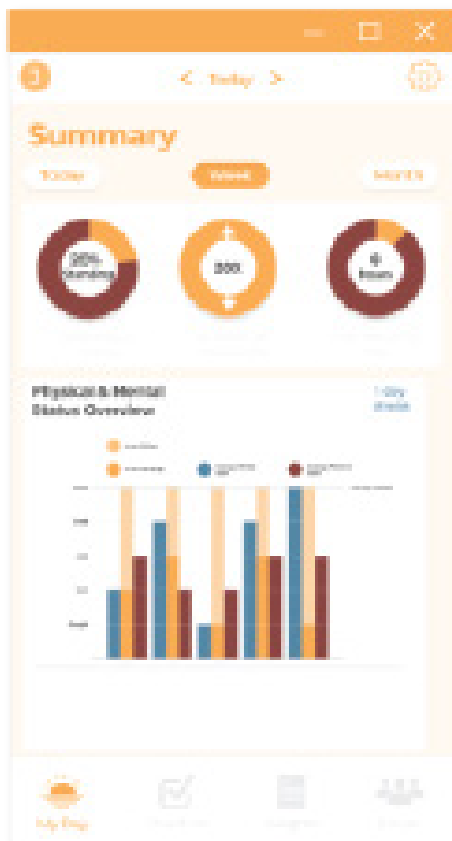
BMDESK CONTROLLER

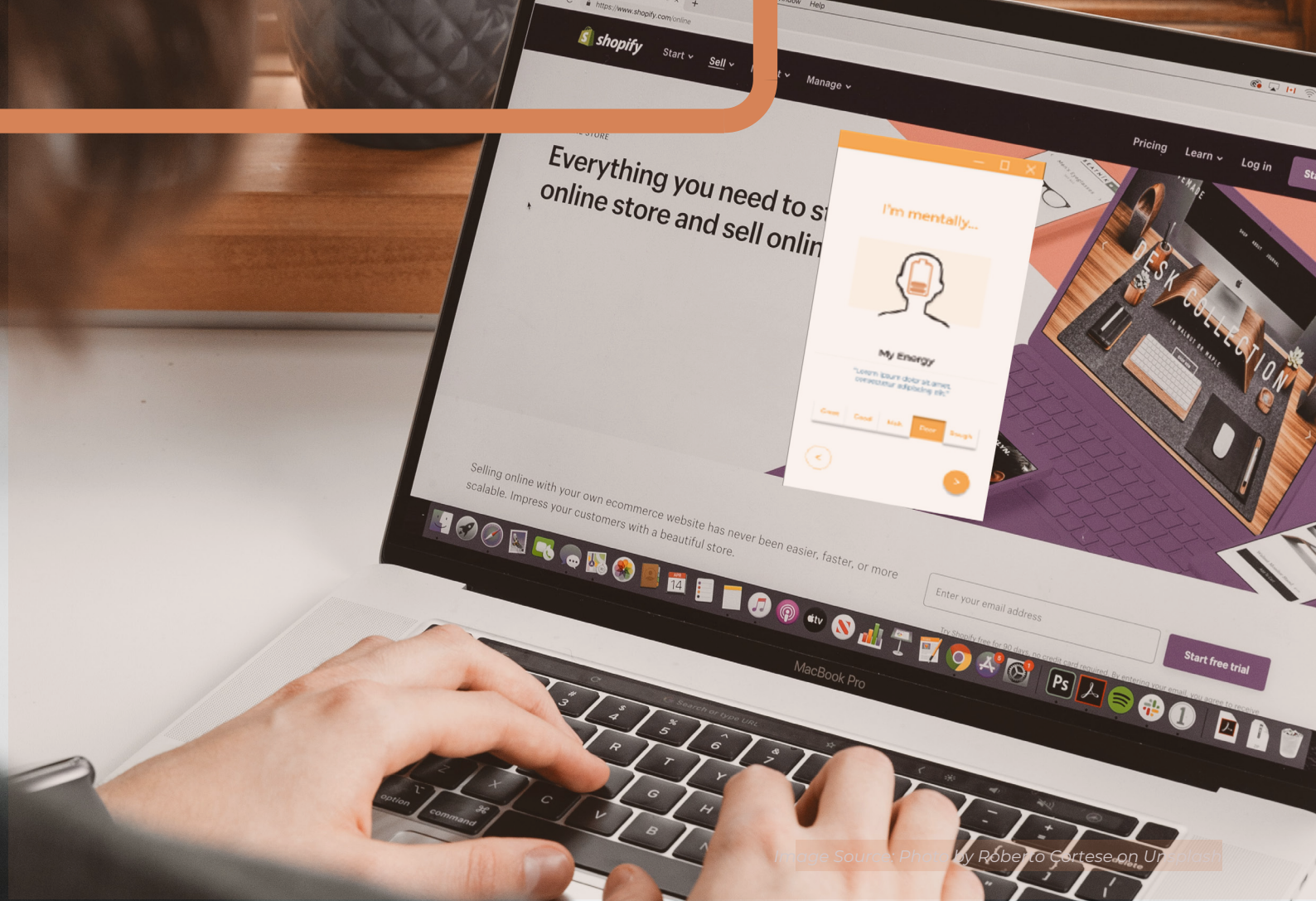*To help working adults in developing the body & mind check-in habit and using it to alter between sitting and standing, the Hook Model states that they need a trigger or reminder that they can associate with the action. Following the user study and concept evaluation, it was clear that participants preferred to have a physical trigger rather than a digital one. There are several reasons why this is the case. The first is that often reminders on a computer are easy to ignore and click out of since the user already has their hand on the mouse. By encouraging them to take their hand off of the mouse and interact with the device, it will require more conscious thought and lessen their ability to ignore the cue. Second, people want a break from their computer and phone screens, and making the trigger a physical one, provides them with this brief break to look away. And lastly, although the action required is a cognitive one (e.g. body and mind check-in), the final desired action is a physical one (e.g. altering between sitting and standing). By providing a physical prompt for the self-check-ins, it is more likely that the user will associate it with a physical action. For this reason, the BMDesk controller provides a solution that combines light-as-a-cue and the ability for users to easily interact with the digital application without having to look at it. The following section further detail the control and its key elements.*
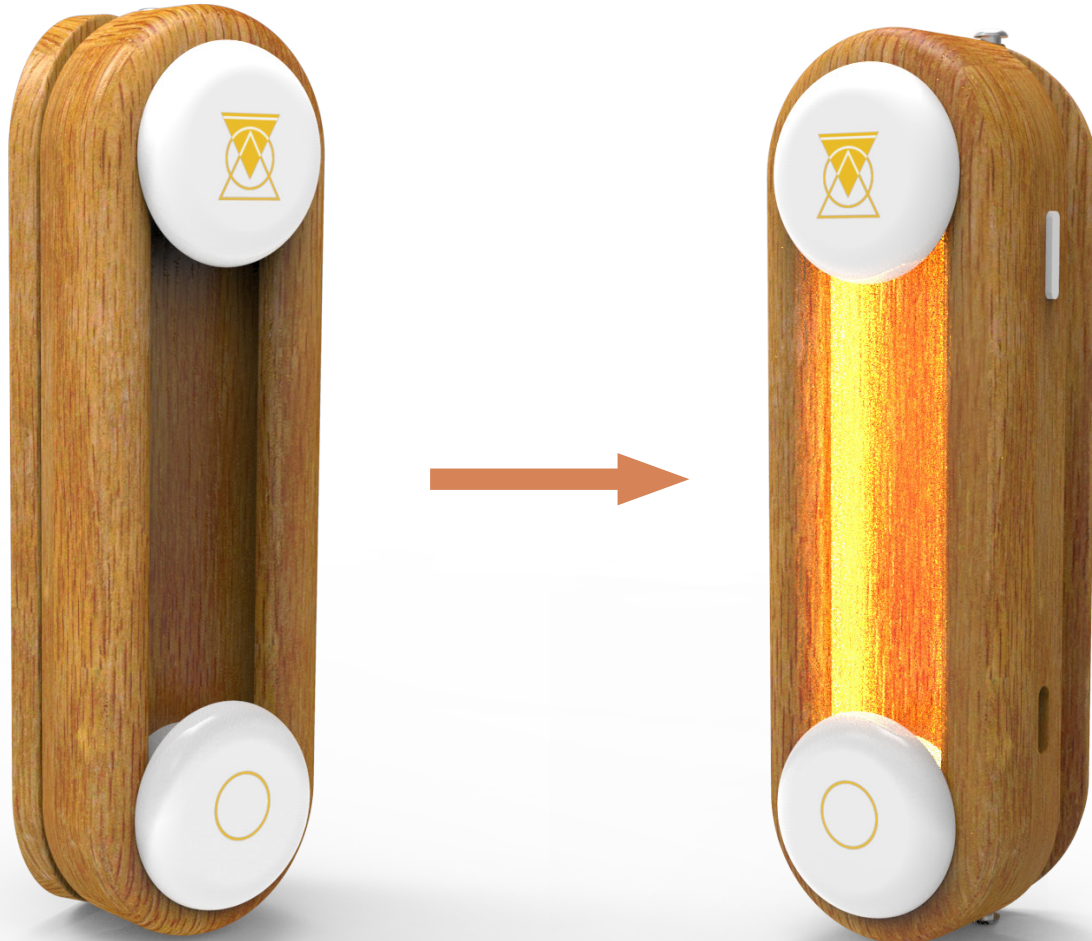
Easy Interaction

By limiting the number of interactions the user has with the controller, it should make it easier for the user to turn their self-body and mind check-ins into a habit, and in turn their sit-stand habits as well. For this reason, there are only three interactions possible between the user and the controller: turning the device on/off, checking in, and snoozing. To easily turn the controller on/off, the user can press a button on the side of the device.

Interactive Touch Sensors

The two additional interactions, checking in and snoozing, are controlled by two touch sensors that are integrated into the device: one found at the top-front (e.g. check-in) and the second at the bottom-front (e.g. snooze). When it is time to check-in and the light-cue turns on, the user can select "check-in" which means that the digital application may open up on their screen indicating that it is time to do a self-body and mind scan, or they can snooze the device for a pre-set amount of time. By snoozing the device, the user indicates that they are busy at the moment but would like to check in later.

Easy Charging

For the final solution, a wired charging method is selected as it is more versatile and generally requires less space than a wireless charger. In addition, the wired charging can be easily plugged into the user's computer while in use.

Automatic Recording of Desk Transitions

To make the interaction between the user and the BMDesk as simple as possible, the controller contains an infrared LED sensor capable of measure the distance between the controller and the ceiling. As the user alters their desk height between the sitting and standing position, the sensor will track these changes and automatically send the data to the digital application where it will be recorded. The user can then use the application to view their progress and further understand how their transitions between sitting and standing affect their physical and mental status.

In the case the user remains in a static position for a very long time, the sensor and application will be able to note this and send a light-cue to the user as a reminder to check-in and potentially alter their position based on how they are feeling.

Check-In *Touch Sensor*

Desk Height Measurement *Two-Way Infrared LED Sensor*

ON/OFF *Button*

USBC *Charging Port*

Snooze *Touch Sensor*
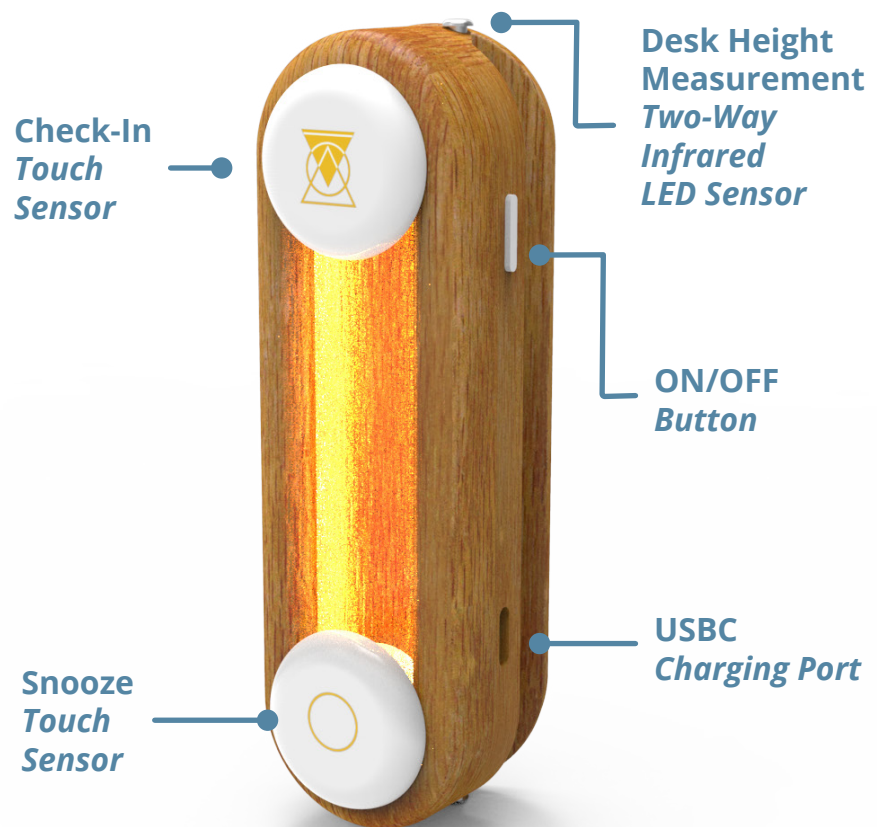
Light Trigger

The BMDesk Controller uses light as a trigger for the self check-in process. When it is time for the user to "check-in" the light gradually fades on and the user can choose to "check-in" or "snooze." A light strip will be integrated into the upper tube on the device which has a slit near the base. The light will shine through the slit. By designing for this lighting experience, the lighting presents a calming and relaxing view that has a comfortable level of illumination without too much glare.

Gradual Change

To reduce the breaks in concentration working adults may feel when using the BMDesk, the light trigger will consist of a gradual transition. This means that when it is time to check-in, rather than just turning on, the light will slowly fade in. This fade-in will allow the users to note that it is almost time to check-in without feeling as if they need to do it at that exact moment. During the testing described in Appendix VIII, the gradual change allowed for the least distractions and although it could be ignored, it allowed the user to notice it when they were ready. This gradual change also falls in line with the desired form and experience described later on in this section of the report

LED Bulbs

After evaluating the different types of light bulbs in Appendix IX, LED bulbs were selected for the final product. LED bulbs provide an energy-efficient, durable, and cost-effective solution that is capable of dimming in and out. In addition, the bulbs come in various forms and sizes making them an easy option to integrate into the device.

Personalized Color Selection

When setting up the digital application, the user is able to select which color or combination of colors, they would like to use as their light-cue. This option is not essential but provides the user with a sense of personalization with the device. This color will be reflected in both the light change and touch-sensor buttons.
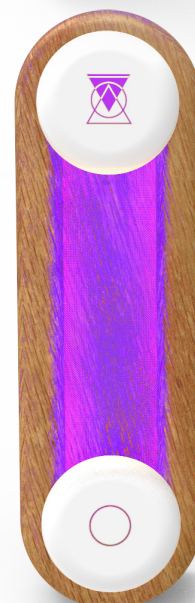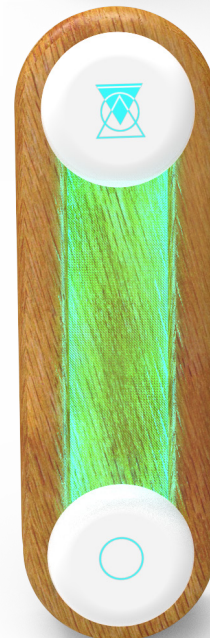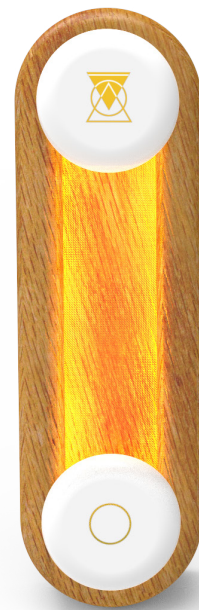
Material & Color Selection

As the product aims to promote mindfulness and body and mind awareness to promote the transitions between sitting and standing, it is also important to consider mindful materials. For this case, online research was done to find materials that are both sustainable and fit the desired aesthetic appearance.

Bamboo

Bamboo is a member of the grass family that grows quickly, protects soil erosion, and is highly sustainable, strong, and flexible. It has a beautiful aesthetic appeal that is both elegant and natural-looking and has many additional benefits such as (Benefits of Bamboo Products, 2021):

- It is durable with a tensile strength of about 28,000 pounds per square inch
- It is resistant to rot and warping due to moisture
  It is naturally UV resistant
- It has a lower carbon footprint than FSC certified tropical hardwood
- Bamboo products imported to Europe have more eco-costs than local European softwood.
- It has a higher yield than trees and currently bamboo has a higher market value
- It requires less maintenance than wood
- It is 100% biodegradable

For these reason, bamboo products are quickly replacing many plastic items and is a viable option for the BMDesk controller.

Bio Plastics

A bio plastic is a plastic that is made partly or wholly from polymers derived from biological sources such as sugar cane, potato starch, or the cellulose from trees, straw, and cotton. Some of these bio plastics are able to mimic the robustness and durability of conventional plastics and present an effective option for parts of the final product.
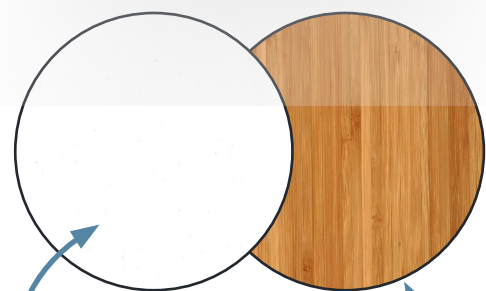
White Bioplastic   **Bamboo**

Versatile

One of the limiting factors of the initial concept: Body and Mind Mouse, was the lack of versatility the solution offered. Several of the participants were concerned that not everyone uses a mouse and often people prefer a specific type of mouse. Therefore, the final solution is designed to allow for versatility and provide the user with the decision on where they choose to place the BMDesk controller.

Clip Attachment

This versatility is supported by the addition of a clip that can be attached to the monitor or other elements around the working adult's desk or it can be locked in place and used as a stand. By adding this element, the user can ensure that the controller is positioned in a way that is easily accessible and viewed.

Conclusion

The BMDesk Controller combines a digital and non-digital product designed to aid working adults in reducing their sedentary behavior by becoming more aware of its effects on their bodies and mind. The product provides a simple solution that reminds users when it is time to do a self-check-in and see how their body and mind are feeling and then provides personalized tips on how to use their sit-stand desks so that they can feel better and optimize their work experience. Users can also use the BMDesk Digital Application to check in on their progress, learn more about better workplace practices, and join social networks aimed at promoting physical wellbeing in the workplace. By joining the social networks, users can feel less alone and supported by a community of their coworkers who are all going through the same process

Propulsion Connection

Requirements
Maximum takeoff weight
Maximum payload weight
Maximum vehicle length
Maximum vehicle width
Maximum vehicle height
Minimum Cruise Endurance
Distance range shall be maximized
Center of gravity from shaft
Minimum vehicle lifespan
Vehicle interior shall be designed to optimize user experience
Vehicle shall follow typical regulations for emergency aircraft
Vehicle shall be aerodynamically feasible
Maximum access to patient / EMT optimization (degrees)
Vehicle exterior shall be reliable / trust /?

Overall Project Design Requirements

Expertise Area	Requirement
PE	
PE	
SDE	
SDE	
AED	
AED	
SST	
SST	
AEF	
AEF	

Design Requirements

I'm physically...

My Lower Back

"Lorem ipsum dolor sit amet, consectetur adipiscing elit."

Characteristics

... of Talaria & adjust to ours

Summary Page | Interior User Experience | Exterior User Experience | Landing Gear Design | Propulsion Connection | Battery | Interior Walls_Floor

TEST

EVALUATING THE FINAL CONCEPT

10
TESTING THE CONCEPT

Contents

EVALUATION OF THE BMDESK

Sitting is a habit and although companies are increasingly implementing new practices in the workplace aimed at reducing this behavior, working-age adults lack the motivation to adjust their static workplace behavior for a more active one. Therefore, the goal of this project was to design a solution that provides the tools to support and encourage desk-based working adults towards utilizing their sit-stand desks and reducing their daily sedentary behavior.

The body and mind are powerful tools when it comes to behavior change, and the BMDesk App and Controller aims to take advantage of these tools to help working adults become more aware of how their sedentary behavior affects their mental and physical state. The goal of the product is that as users gain this information, they will be better able to make a positive change.

Evaluating the Final Concept

The final phase of the design process involves a proof of concept where the BMDesk App and Controller are evaluated against the requirements set in the "Design Focus" to determine whether it meets the design goal. To accomplish this task, the final concept is tested upon the notions of desirability, viability, and feasibility. In each category, the following questions, which are related to the initial requirements, are posed:

Desirability
Do users believe that the concept contains the tools necessary to aid them in reducing their sedentary behavior at the workplace?

Viability
Are users willing to pay for the product or request it from their employer?

Feasibility
Can a working prototype be made?

Proof of Concept: Desirability & Viability

The first step in evaluating the BMDesk App and Controller is to determine whether the concept is desirable to the target group and economically viable.

Research Method

To gauge the user response, an online questionnaire was created and sent out to twenty potential participants. The questionnaire began by asking each participant about their typical workday experiences to determine whether or not the participant fell into the target group.

Next, participants were provided with a short introduction to the project and the final concept. The UX prototyping website, Figma, was used to rapidly build a digital application that provides an overview of what the app is meant to do. Also, a storyboard and render were provided to guide participants through the user journey and present an idea of how the users would interact with the controller in real life. Once users were able to get a better understanding of the final design, they were asked to fill out a design goal evaluation.

Overall thirteen individuals completed the online questionnaire but only seven fell into the desired target group. Responses from all individuals were taken into account, however, the responses of those falling into the target group were reviewed more closely.

Quantitative Results

Figure 36 shows the average scores of the design goal evaluation. The BMDesk rated relatively high in its ability to reduce participant sedentary behavior while also providing them with a sense of autonomy (control) over their decision to alter positions. However, the final concept did not rate high in its ability to aid users in their sense of relatedness and competence, therefore not fully fulfilling the three basic needs of the Self-Determination Theory of motivation.

User Survey Results

1. To what extent do you believe this device would aid the long-term reduction of your daily sedentary behavior?

2. To what extent do you feel that you would remain in control over your decision to sit or stand?

3. To what extent do you believe the product would provide you with peer support?

4. To what extent do you believe the product would enable you to better understand how to best use your sit-stand desk?

5. How interested would you be to ask your employer to provide you with this product?

6. How much would you be willing to pay for the product?

Users provided mixed responses as to whether they would be interested to receive the BMDesk from their employer, although a majority rated this element above a 4. This corresponds to user interest in the product, as although the amount they would be willing to pay falls lower on the scale, it still falls within the desired price range set for the final product.

Qualitative Feedback

Overall participants within the target group felt positive about using their own body & mind, combined with a trigger and personalized tips/recommendations, as an indication to alter their posture and transition between sitting and standing at work.

"I think it would be highly appreciated to become more aware of how my body is feeling. I would definitely try to adapt my behaviors based on the device recommendations."
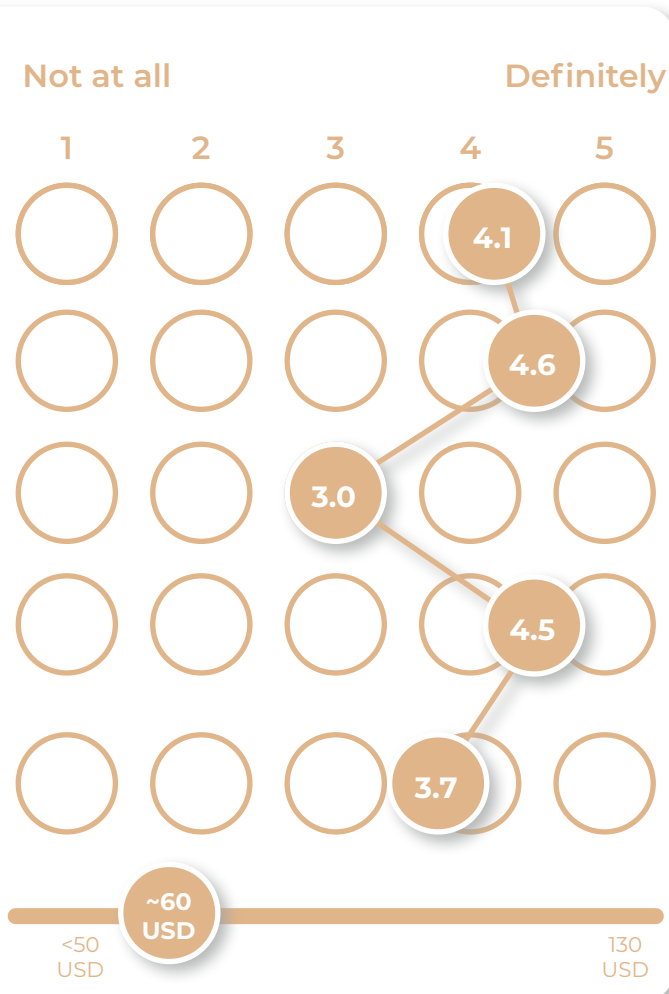
Not at all   Definitely

1   2   3   4   5

4.1

4.6

3.0

4.5

3.7

~60 USD

<50 USD   130 USD

Figure 36: User goal evaluation results.

"I think it would help me be more mindful of the way I am interacting with my work environment."
"As recommendations are different according to how I feel mentally and physically I think I will be able to understand when to use each working position better over time"
"I didn't get any instruction from my employer so I don't have a good idea of what can be fixed by standing. I think the personalized tips could help me understand better."

But there was a common concern among several participants that even though it might be effective in the short term, over time they would become less committed and potentially stop engaging with the app.

"My worry is that, as with many other tools, I would eventually get tired of answering the questions. The fading light helps, but still..."

There were also mixed feelings about the social element of the app. Although some users liked the idea that they could work with their colleagues and plan when they would stand-up during the day (e.g. at meetings or during coffee breaks), many participants felt that the social element was either unnecessary or that in their current work environment, people would not use it.

"The app looks like a great support considering that it provides tips according to different situations and builds also a community among peers"
"It would only work if others at my office also had this and were actually using its capabilities"
"The social aspect might help but I also do not think that in my company environment my coworkers would actually use it..."
"Changing my behavior is personal, so I wouldn't use that part of the product."

Finally, a majority of participants ranked their desire for their employer to provide them with the product relatively high, especially if the product was reasonably priced. They often liked the idea that it focused on improving employee wellbeing and, in turn, job satisfaction. Although not all participants in the target group felt this way.

"It would result in better office experience, higher job satisfaction but also efficiency."
"It would be nice to have but I feel neutral about asking for it if it is not offered."

Conclusion

Although the results look relatively promising, nothing can be said about how this product will evolve over a longer period and whether it will be enough to encourage desk-based working adults to utilize their sit-stand desks more often. In addition, there were many mixed feelings about different elements of the concept, and moving forward, further evaluation and design iterations should be considered as well as long-term testing of the product itself.

Also, further evaluation should be done with employers to determine that even if their employees are interested in this product, is it something that they would be willing to supply them with.

Proof of Concept: Feasibility of the Controller

To prove the feasibility of the BMDesk controller, the question is posed as to whether a working prototype can be made within the project time frame. For the proof of concept, three significant assumptions are tested.

Assumption 1:
A working prototype can be made that can provide the gradual fade-in light-cue to the user and then accept the user's decision to "snooze" or "check-in."

Assumption 2:
The controller will be able to automatically track the user's desk transitions between sitting and standing by using an infrared distance sensor to measure the change in distance of the desk from the ceiling.

Assumption 3:
The controller will be able to determine if the user is in a static position for too long and send a signal to trigger the light-cue.

To test these assumptions and provide proof of feasibility for the BMDesk controller, the following equipment is used:

- Seeeduino Lotus Circuit Board
- Time of Flight Distance Sensor (VL53L0X)
- 2 x Arduino Touch Sensors V1.1
- Grove Chainable RGB LED V2.0 (for the final image, a chainable RGB LED strip was used)
- Ultimaker 3D printer & PLA filament
- Arduino IDE Application

Creating the Prototype

The first stage in creating a working prototype was to develop a flow chart specifying how the controller should work. Once the flow chart was completed, the code for the controller could be written in the Arduino IDE application. This code was written with the help of an outside Software Engineer. This flowchart is presented in Figure 37 and the final Arduino code can be found in Appendix XI.

As the Arduino components were too large to create a 1-1 scaled prototype, a 1-2 scaled prototype was created to present how the final device should look. Solidworks was used to 3D model the controller and an Ultimaker 3D printer was used to print the case and frame of the controller.

In the final result, it was apparent that the Grove Chainable LED used to create and test the Arduino code did not provide enough light for the final desired result. Therefore, an RGB LED strip replaced the Chainable LED to present the final look for the 2 x scaled device.

Results

Assumption 1

To validate assumption 1, just the Arduino IDE Application to write the code Seeeduino Lotus Circuit Board, two Arduino touch sensors, and the Grove Chainable RGB LED were necessary. The Arduino code for this setup can be found in Appendix XI.

The results of this set-up proved to be successful, as a working prototype could be made..

Assumption 2

For the BMDesk controller to be deemed feasible, one of the assumptions states that it must be able to automatically track the change in desk height based on the change in its distance from the ceiling. This assumption was validated using a two-phase process.

Phase 1: Develop the Arduino code using the Arduino IDE Application to write the code, the Seeeduino Lotus board, and the Time of Flight Infrared Sensor (VL53L0X).

Phase 2: Test the code to ensure that it is capable of understanding when the desk height is altered based on the change of distance of the desk from the ceiling.

A picture of the set-up for Phase two can be found in Figure X. As shown in the figure, the distance sensor was placed at the height of the computer and directed towards
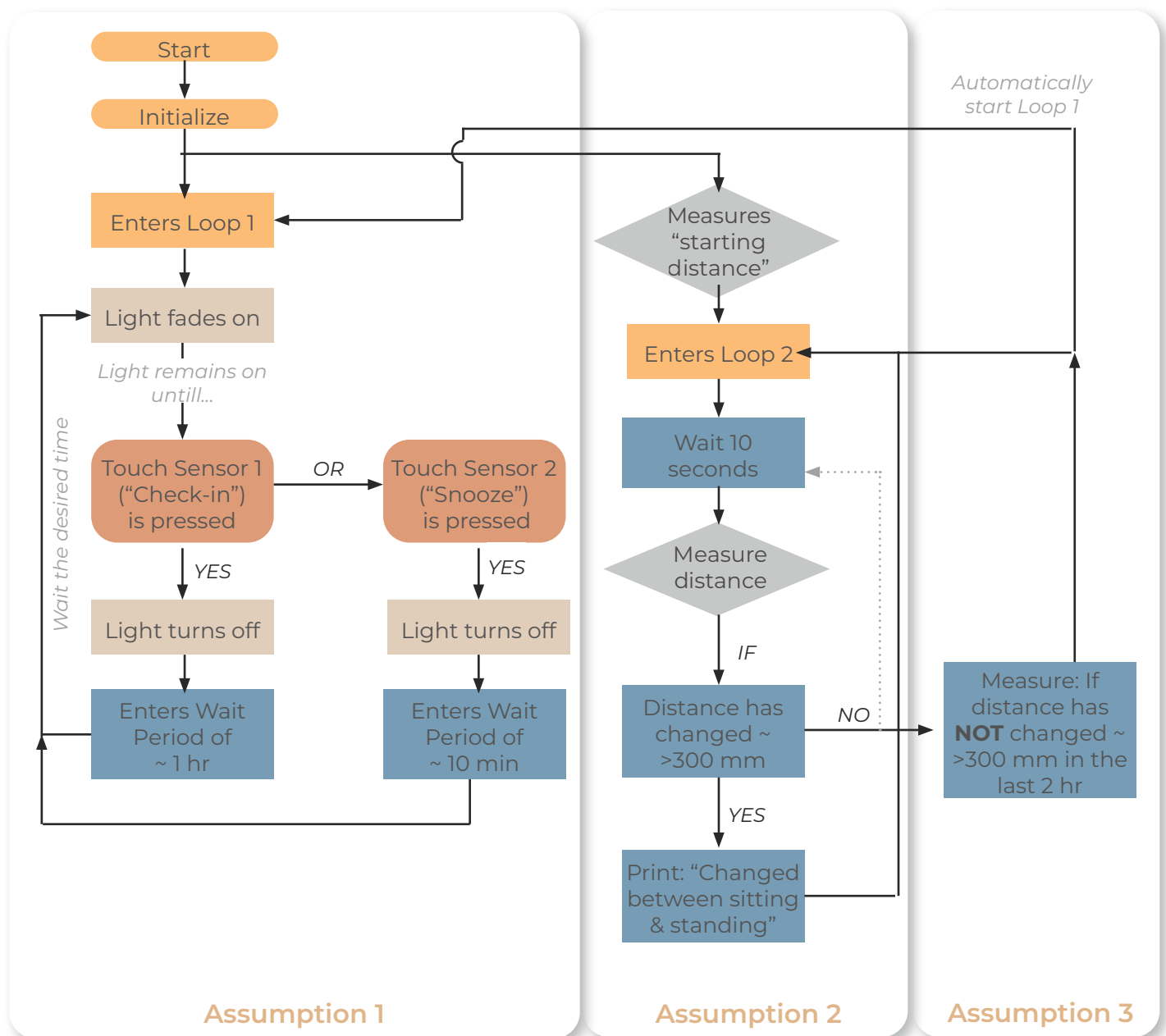
Figure 37: Flow Chart for the final Prototype

Assumption 1

Start

Initialize

Enters Loop 1

Light fades on

Light remains on untill...

Wait the desired time

Touch Sensor 1 ("Check-in") is pressed

OR

Touch Sensor 2 ("Snooze") is pressed

YES

YES

Light turns off

Light turns off

Enters Wait Period of ~ 1 hr

Enters Wait Period of ~ 10 min

Assumption 2

Automatically start Loop 1

Measures "starting distance"

Enters Loop 2

Wait 10 seconds

Measure distance

IF

Distance has changed ~ >300 mm

NO

YES

Print: "Changed between sitting & standing"

Assumption 3

Measure: If distance has **NOT** changed ~ >300 mm in the last 2 hr

Image: 2x1 Scaled Working Prototype
Image Source: Photo by Michal Adar

the ceiling. Upon initialization, an initial distance was recording and displayed on the ArduinoIDE Application serial monitor. Next, the desk was raised to the standing position. Once the Arduino code measures the alteration in the desk height, it displays "Changed between sitting and standing." This test was conducted again after the desk was lowered back to the sitting height.

Although the Arduino code worked as intended and the distance sensor was able to note when there was a transition in the desk height between sitting and standing, the distance sensor was not strong enough to make this detection based on the distance of the desk from the ceiling. For this experiment, the paper had to be used instead as the distance sensor was only able to measure up to two meters away from the desk.

To validate this assumption, a calculation was needed to determine how powerful the distance sensor needs to be and then research was done to determine whether the corresponding distance sensor is available on the market. This calculation is presented in Figure 38.

To determine the distance required for the sensor to work, several dimensions were set based on information from the Jones(n.d.) (D1), Rybczynski (2017) (D2), and Middlesworth (2015) (D3).

D1: Minimum desk height when seated - 59 cm
D2: Higher ceiling height ~4.0 meters
D3: Monitor tilt angle - up to 30 degrees

As shown in the Figure, the distance that the distance sensors need to be about to measure is about 5.0 meters. According to an online search, there are distance sensors capable of measuring 5 meters or more (eg. the Adafruit VL53L0X Time of Flight Distance Sensor). Therefore this assumption can be deemed feasible.

Assumption 3

For the final assumption to be validated, the code created for assumption 1 and assumption 2 needed to be combined with additional code calling for assumption 1 to start in the case that the desk height remained static for more than 2 hours. This code proved to work and can be found in the final code included in Appendix XI. Therefore, the assumption can be deemed feasible.
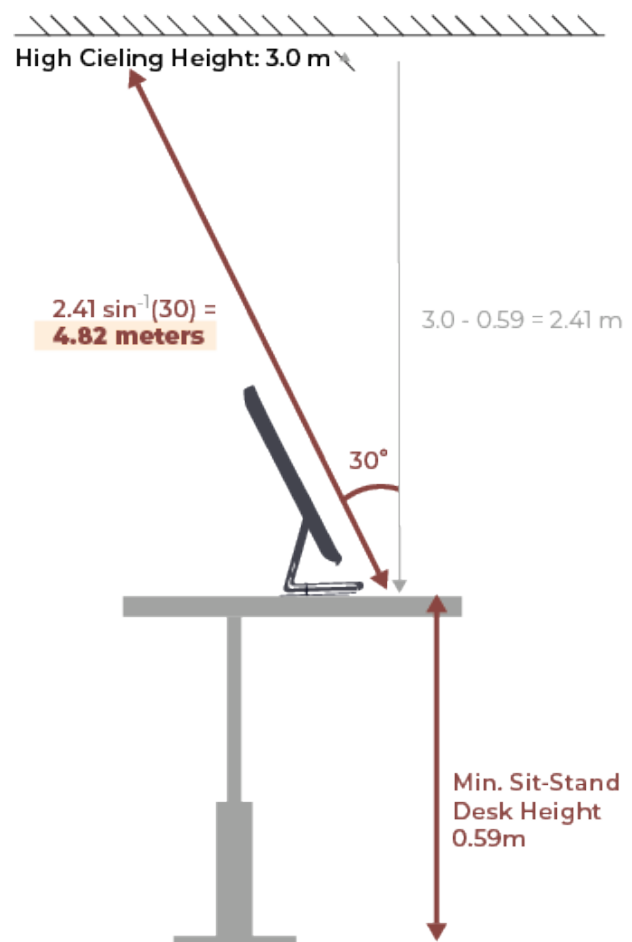

High Cieling Height: 3.0 m

$2.41 \sin^{-1}(30) =$ **4.82 meters**

3.0 - 0.59 = 2.41 m

30°

Min. Sit-Stand Desk Height 0.59m

Figure 38: Calculating the power required for the distance sensor to work in an office building with high cielings.

Conclusion

Based on the ability to create a code and rapid prototype capable of fulfilling all three assumptions within the desired time frame, the feasibility of the BMDesk Controller is validated.

Although the controller can not yet be connected to the BMDesk application, there are many products/digital application combinations already existing on the market, so it can be assumed that this element of the final concept will work.

Another area for consideration is that one of the workplace trends mentions the possibility that the future will consist of a hybrid work environment, where remote working will be more popular. When conducting remote work, many different types of environments working adults work from. This means that although the controller can be used in the typical office building or open office space, there is a large possibility that it cannot be
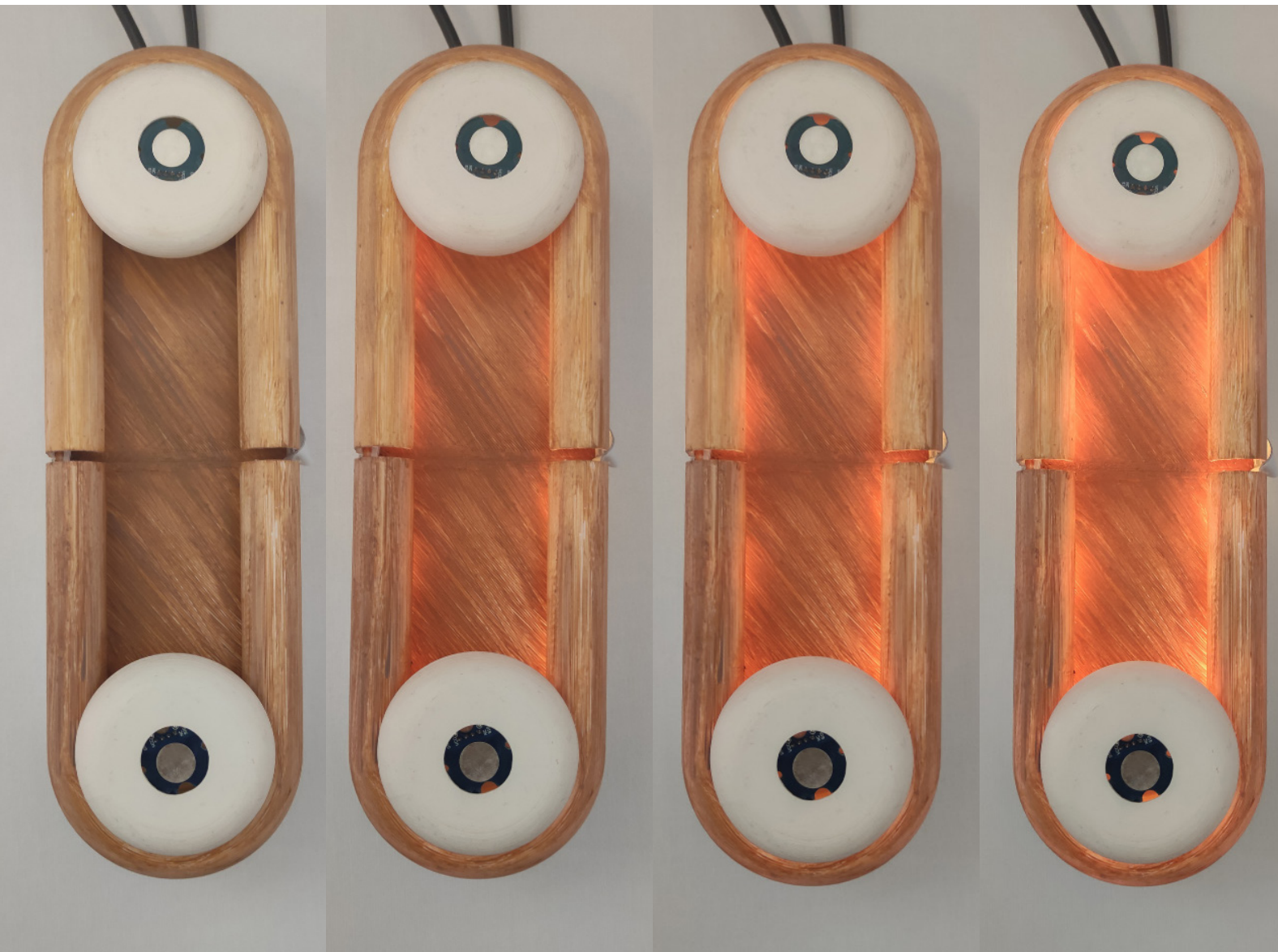
REFINE

LOOKING TOWARDS THE FUTURE

Image Source: Photo by Harmoni Desk on Unsplash

11

MOVING FORWARD

Contents

FUTURE DEVELOPMENT

Recommendations

The goal of this thesis is to design a solution capable of reducing the sedentary behavior of desk-based working adults. Although the results of the final evaluation look relatively promising, there are still many design interventions to be realized. To refine the BMDesk App and Controller and create a recommendation for moving forward in the design process, feedback from the user evaluation is considered, and a small focus group was held. The focus group involved assessing how the final product is experienced and brainstorming on how to best improve upon it. The focus group was done with four other design students. Two prototypes were used for the assessment. A 1-1 scaled and painted prototype to evaluate the aesthetics of the final product and a 2-1 scaled working prototype, from the feasibility testing, to present the interaction with the product. An overview of the method taken for the focus group can be found in Appendix XII.

Conducting a focus group to improve upon the product experience adds to the agile design process to define the areas in which the product could be improved upon. The outcomes of this session, as well as personally defined recommendations, are included in the following sections.

The following recommendations are divided into the two main components (the BMDesk Controller and the BMDesk App) and their subcomponents to present detailed ideas for further the design.

Image: 1x1 scaled prototype

Image: 2x1 scaled working prototype

The BMDesk Controller

Aesthetics

- **Reduce the Size**
  Since the main idea is that the controller is meant to be clipped onto the side of the monitor, it is suggested to reduce its size so that it does not obscure the user's view of their screen.
- **Redesign the Look**
  The participants who interacted with the device thought that it looked like a joystick and the two circles with touch sensors were meant to be slid from one side to the other to "snooze" or "check-in." Although this assumption can be adjusted with the addition of a manual explaining how it works, the goal of the final product should be that it is intuitive. Two ideas to adjust this include either filling in the gap or better differentiating between the two buttons (touch sensors)
- **Provide a diverse color scheme / materials**
  Participants were asked to select what color scheme they believed would best suit a device that was both meant to reduce their sedentary behavior and easily integrate into their workspace. Participants were provided with six options and the results indicated that most of the users have very different preferences. The top two selected schemes are shown below. One is the scheme of the current device.

- **Medical vs. Mindful**
  It is suggested to test user experience when the device is designed to have a more mindful aesthetics vs. a medical aesthetic. When users were asked, there were mixed preferences. Some users preferred a more medical look as it would be "sleek" and the final solution is meant to reduce the adverse health effects they may encounter while others preferred a mindful aesthetic as they believe the initial goal of the device was to aid them in becoming more aware of how they were feeling and use that to alter their position.
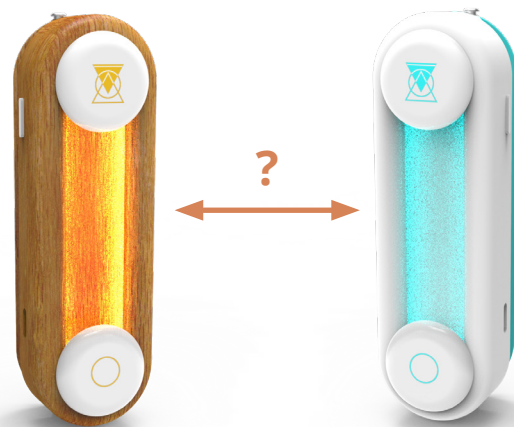
Light as the Trigger

Rather than just using the light as a trigger to remind the user to check it and alter their sit-stand position, the light could also be used to do more.

- **Light as an indication of how you are doing**
  The light on the controller could be used to indicate to the user if they are doing well and reaching their sit-stand transition goals, or if they are not doing and are remaining in a static position for too long. There are various ways the light could indicate this to the user (e.g. flash red if not doing well, fade green if doing well) and the different ways should be tested to determine which provides the desired result and optimal experience.
- **Light to indicate when a goal is complete**
  Users can pre-set goals in the app to indicate how often they want to check-in or transition between sitting and standing

per day. The light on the controller could be used to indicate to the user when they have completed a goal. This could be done by providing a little light show which could be seen as a reward for their accomplishment.

- **Light to indicate when the user is "snoozing" too much**
One concern many users had was that they would only hit "snooze." For this reason, the light could be used as an indication that they are hitting "snooze" too often. One idea to improve upon this is that if they hit snooze a specific number of times in a row, the light will slowly fade on and off until they take a moment for themselves and touch the check-in button.

Versatility

- **Provide Alternative Ways to Put On Desk**
Many participants were unsure if they would want to have to controller on the side of their computer monitor and were unsure if they could leave it on the screen in case they worked in a hybrid environment. Many of the users mentioned that they would prefer the device to be placed on the desk, although they knew that this would put it out of sight, which may affect how often they notice it.
- **Add a way too tell when the user is away from their computer**
Participants indicated that the main time that they would not like to use the BMDesk controller is when they are in meetings as the light trigger might go off and it could be distracting. For this reason, the controller should have a way of noticing when the user is away from their desk or in a meeting. To do this, the controller could either have some sort of heat sensor or connect to the user's calendar and automatically "snooze" when the user has indicated that he/she will be in a meeting.

The BMDesk Application

- **Adjust the body & mind self-scan tool color code**
Participants were often confused by the colors when they were evaluating the different areas of their body and mind on a scale of Rough to Great. These colors should be adjusted so that they correlate to colors that people are already familiar with when evaluating discomfort/comfort levels. One idea is to mimic the colors used in the Apple Fitness app as people are used to it and it typically has a clear indication. Further research in this area should be done.
- **Clean up the Graphs**
The graphs on the application should be simplified and altered to match existing physical representation data that people are already familiar with.
- **Save the Articles for Later**
After the user completes filling out the body & mind self-scan tool in the application they are provided with a short tip on how to adjust their position and a link to a full article. Many participants thought that even though they would like to read the article and have the information, it would be too much and too distracting to read while at work. An option to change this is to summarize the article into a short blurb and if users want to read the full article, they can save it and read it on their own time.
- **Provide notifications to tell user what will happen if they do not alter habit**
One element that the Apple Fitness Application has that several participants liked was that if they did not perform a certain action (e.g. drink water when they woke up) the app would notify them about what would happen later in the day because they didn't take this action. Some users thought this would be a nice addition to the app, but there were also many feelings that by adding this element the app would become too aggressive, and less motivated users would not like it. This is something that should be tested.

Further Testing

Altering a behavior and forming a new habit does not happen instantaneously. Although many promising insights were gained from all of the user interviews and evaluations, it is difficult to understand whether this product will work over a longer period.

To determine whether or not the final product will be successful in the market and among the target group, it should be refined according to the mentioned recommendations and tested with desk-based working adults over a longer period to see whether or not it results in a reduction of their sedentary behavior.

The Final Product

One of the limitations of the final concept is that it can only be used to reduce the sedentary behavior of sit-stand desk owners. Although this target group is growing as more companies are installing sit-stand desks in their offices, there are still many working adults who do not have access to the desks or are working from remote locations.

An idea to improve this aspect of the product is to broaden its scope and focus on promoting the physical wellbeing of all desk-based working adults, rather than just focusing on those with sit-stand desks as the sedentary phenomenon is a very large issue around the globe.

PERSONAL REFLECTION

During the past few months, I have learned so much from working on this graduation thesis, and although I faced many challenges along the way, I think I was able to overcome them and excel as a designer.

You can keep it simple.
My graduation thesis felt like an amazing opportunity to really dive into user research and further develop my expertise in this area. Although I do think that I successfully accomplished doing this, the key thing that I learned was to keep it simple. For my initial user interviews, I had planned to do a quite extensive context mapping session that unfortunately did not work as my target group often did not have the time to participate in this kind of study. Therefore I had to simplify and change the context mapping to interviews. From this change, I realized that sometimes it is ok to keep things simple as people often know their own experiences and you will often get great insights from just discussing with them.

Things don't always go according to plan.
At the beginning of my thesis, I had created extensive planning for the entire duration of the graduation thesis. But, as I learned relatively quickly, things do not always go according to plan and adjustments often need to be made. By working on this project, I learned how to make these kinds of adjustments quickly and efficiently and often ended with even better outcomes than I could have initially expected.

Analysing the Data is Fun
Something that I did not expect was that I enjoyed analyzing the data from the user research and interpreting the results. At first, I wasn't sure how the best way would be to do this, but there are so many different methods and by reading about them I was able to figure

it out. I also had the opportunity to interview people from the USA, the Netherlands, and Israel. Even though these three environments are quite different, and the perception of work varies, it was so cool to see how all the different participants often had very similar experiences.

I miss working in a team.
One of the most difficult things for me to do was adjust from working with a team to working alone. In the past, I have always had a team where the project tasks were divided according to each member's strengths and there were always people there to brainstorm with and provide motivation. But, for this graduation thesis, I was working alone and everything needs to be done by myself. At first, going into this project I was excited for this opportunity to show off what I can do and my work, but now that the project is over, and although I do think that I did a great job managing my project and presenting my design process, I have realized that I do love the team atmosphere.

The overall exeperience.
As a designer, this project was incredibly valuable to my development. I learned so much about conducting user research and designing for behavior change., and I really enjoyed being able to put my personal touch on the design process. The final product fits within my design goal and with further development and implementation it could really help to reduce the sedentary behavior of working-adults. Overall I am proud my outcome and of how I developed myself throughout this project.

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