FitViz-Ad: A Non-Intrusive Reminder to Support and Encourage Rheumatoid Arthritis Patients with Physical Activity

by

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Abstract

Advancement in wearable devices has allowed users to easily capture and monitor their physical activity data. There is a growing interest in using the data captured by these devices for self-management of chronic diseases. However, wearable devices in the market today are generally designed for people with no physical restrictions who try to get fit. Wearable devices like Fitbit and Jawbone UP recommend users to take 10,000 daily steps [30, 22]. Fitbit sets this as a default recommended goal for its users. However, this recommended goal is not appropriate for people with chronic pain such as people living with rheumatoid arthritis (RA). Currently, this group of people lack appropriate health and fitness tools to help them collect and manage their activity data without having to customize multiple settings with the tools available on the market today.

People with RA struggle to be physically active because of the pain caused the inflammation around one or more joints in the body. This inflammation causes significant discomfort for them to be physically active [1]. Doctors tend to encourage patients to achieve certain activity goals every day to keep their muscle strong and joints flexible. When one is not physically active or tend to avoid physical activity, their muscles get weaker and they lose flexibility in their joints. Thus, people with RA are encouraged to be physically active to help manage and maintain the disease [11, 19, 47, 60, 71].

We developed a non-intrusive reminder as a Chrome browser extension called “FitViz-Ad” to help arthritis patients track exercise and measure if they are meeting the activity goals set by their doctors. FitViz-Ad replaces online advertisements with reminders for the users to get up and walk around if they have been sedentary for too long. We conducted a usability study to evaluate FitViz-Ad as a non-intrusive reminder by recruiting fourteen healthy participants for a 2-week study. Participants were required to wear a Fitbit tracker for the duration of the study which their physical activity data was collected and analyzed. Each participant was then interviewed at the end of the study about their experience and thoughts on the extension.

Results from the study showed no significant increase in participants’ physical activity while using FitViz-Ad, however qualitative results from the interviews showed that participants were more aware of their physical activity during the study.
Keywords: Personal Informatics, Arthritis, Personalization, Reminder, Non-Intrusive
Dedication

This thesis is dedicated to my parents, who are my living gods. You are so selfless in what you do and have sacrificed so much for us. All my achievements would not be possible without you and there is no word in the English dictionary that can justify my appreciation for your unconditional love and support. THANK YOU.

I also would like to dedicate this thesis to my sister and all of my family members who have been with me through thick and thin. THANK YOU.
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Chapter 1

Introduction

In recent years, there is a surge in popularity of wearable devices worldwide ranging from wearable pedometers to smartwatches that can track user’s physical activity [88]. With several large technology companies such as Apple, Google and Samsung taking interest in reaching out to consumers with wearable devices that support health and fitness [56], it may suggest that wearable devices popularity will keep on growing. Smartwatches and fitness monitors are expected to increase in sales from 51.39 million units in 2015 to 91.79 million units in 2017 [88]. This growth is a positive trend that would encourage everybody to be physically active and healthy.

However, wearable devices in the market today are generally designed for people with no physical restrictions who try to get fit. For instance, Fitbit and Jawbone UP recommend users to take 10,000 steps, based on recommendations from the National Sleep Foundation and the World Health Organization [8, 30, 22]. This recommended daily step count can be intimidating and may not be an appropriate target for people with chronic pain such as rheumatoid arthritis patients (RA) [81].

In this thesis work, we will introduce a Chrome browser extension called “FitViz-Ad” that replaces online advertisements on web pages with reminders to help users to be physically active. FitViz-Ad is intended to help RA patients that have sedentary office jobs and
spend a majority of their time sitting to be more physically active. In the following sections, we will discuss in details about rheumatoid arthritis, its effect on quality of life and why physical activity is encouraged to maintain the disease.

1.1 Impacts of Rheumatoid Arthritis on Quality of Life

Rheumatoid arthritis (RA) is a type of arthritis that causes swelling and pain in and around the joints through inflammation. RA is also called a systematic disease due to its effect on body systems including the cardiovascular or respiratory systems [1]. With the pain and discomfort caused by this disease, RA patients may face difficulties with mobility and functional independence which can severely impact one’s quality of life [26]. On top of that, RA is also known to cause anxiety and depression [29].

The treatment for RA focuses on decreasing inflammation, limiting joint destruction and disability. Nonsteroidal anti-inflammatory drugs (NSAIDs) are generally prescribed to patients to ease the pain and inflammation while surgery is another option for patients with permanent damage that limits mobility and independence [71, 2]. To successfully manage arthritis, patients are recommended to maintain a physically active lifestyle. This recommendation is supported by several research studies that suggest that various forms of exercise and an appropriate amount of physical activity are safe and beneficial for people with RA [11, 19, 47, 60, 71]. Patients can discuss with their doctors regarding the appropriate amount of physical activity they can do daily to maintain a physically active lifestyle and improve quality of life. Recommended physical activity from doctors would provide patients with daily activity goals that patients can try to achieve. This recommended physical activity from a professional gives patients a realistic and appropriate target for them to aim for, unlike the default recommended step counts from commercial wearable devices like Fitbit.

However, maintaining a physically active lifestyle requires a great level of motivation and commitment that majority of the population struggle with, let alone RA patients, who
experience pain and discomfort when performing physical activity. A 2009 study showed that 60% of adults in Europe participated in no physical exercise or sports, less than 50% of adults in the US were regularly physically active and only 15% of adults in Canada met national physical activity recommendations [74]. These findings suggest that majority of the population lack sufficient motivation to sustain a physically active lifestyle, thus encouraging physical activity through different motivational techniques should be explored.

### 1.2 Physical Activity for Rheumatoid Arthritis Patients

In order to promote physical activities among people living with RA, they need appropriate tools that can help them manage and keep track of their physical activity level and ensure that their participation is sustainable and not something that they would easily lose interest. With multiple commercial wearable products recommending 10,000 steps a day, one might potentially feel intimidated or discouraged if one cannot achieve the goal. People whose job does not require any physical activity might not be able to achieve the 10,000-step goal and possibly even less likely for RA patients. It was also pointed out that the recommended 10,000 steps can be harmful as it shouldn’t be considered as a goal suitable for everyone [82].

When one repeatedly fails to achieve the set goal, one might not have the self-confidence to become physically active. Consultations with professional doctors or physicians should be recommended to RA patients to find out the appropriate amount of physical activity that they can safely participate in. The physical activity goal can be set in commercial products like Fitbit to accommodate people who struggle with physical activity. We will overview in detail about previous studies relating to the recommended steps and how appropriate amount of physical activity can be beneficial for people with RA in the literature review chapter.
1.3 Research Question: Can Non-Intrusive Reminders Effectively Encourage Physical Activity?

Because we had observed that there are user groups in which the commercial wearable devices today are not accommodating, we are interested in exploring an alternative design that is appropriate for people with chronic pain like RA patients. Through this work, we were keen on using a commercially available product and alter its recommended goal to provide an appropriate activity goal for a population group that product was not originally intended for.

Like mentioned earlier, motivation plays an important factor in making a sustainable physically active lifestyle for RA patients. Our work began as we speculated to why people are not motivated to be physically active. For working adults who work 8 hours a day, they might not be able to find enough time out of their busy work schedule to exercise. For RA patients, being physically active can be a painful, discomforting experience and not something they want to repeat daily. Thus, their motivation to become physically active is diminished. However, instead of thinking of physical activity as a daily workout routine consisting of a 20-minute continuous exercise daily, it can be broken up into small activity segments that one can perform throughout the day. For instance, for an office worker who sits in front of his/her computer 8 hours a day, it would be beneficial for him/her to get up and walk around once every hour or so to avoid being sedentary for too long. This can count toward the physical activity that one performs in a day. Quantifying these small physical activities toward a daily goal and present to RA patients of how much activities they have done throughout the day can potentially be a rewarding experience for them. With their physical activity recorded, they might be more inclined to walk more in the office to try to complete their daily activity goals. Slowly, the daily goal can be increased while still reasonable enough for one to complete the goal can be a practical approach to motivate people to be physically active.
Moreover, people who hold sedentary office jobs might find it hard to move around the office on a busy day. They need a tool that can remind them to get up and walk around for a couple of minutes after a long period of sitting. An activity reminder would be an obvious way to remind them to be physically active. However, reminding one to perform physical activity via visual or audio cues might cause distractions that interfere one from completing the primary task. This distraction can be perceived as a bad experience and may potentially lead one to associate physical activity as a troublesome daily chore that needs to be completed. To avoid having to push people to go out of their way and be physically active, we wanted to explore a more subtle approach to encourage physical activity.

Thus, we developed a Chrome browser extension, called “FitViz-Ad”, which reminds the users to be physically active if they stay sedentary for too long. FitViz-Ad subtly reminds users when they should get up and walk around by replacing online advertisements on web pages with reminders of their activity progress and the daily goal they should aim toward. We believe that by giving people a small consistent "nudge"[75], people would slowly be more inclined to become more physically active. Using this extension, we would like to answer our research question "Can Non-Intrusive Reminders Effectively Encourage Physical Activity?". In the following section, we discuss the approach and methodology we took to evaluate the extension in order to understand the effectiveness of the tool to encourage physical activity.

1.4 Approach & Methodology

In this thesis work, we began by exploring different ways that we could design the extension to be a non-intrusive reminder. We realized that to design something that is subtle and non-intrusive, we needed to abandon the standard behaviour of a traditional reminder, which is something that is designed to distract and grab the user’s attention. A reminder with subtle messages and does not distract one from the main task at hand would be ideal. Thus, it could be something that quietly inserting itself into one’s workspace with no major audio or visual distractions. Because people tend to dislike online advertisements when they surf
the web, we came up with an idea of transforming that negative association into something that is personalized for the user. With that notion as inspiration, we asked 'What if we can remind patients on a website that they’re visiting to get up and walk?'. We came up with two different approaches to answer this question. The first approach was to design the reminder as an online advertisement to be managed and distributed by a third-party service. With this approach, we lack the control needed to remind users at specific times and the content of the advertisement piece is extremely restricted. This approach also creates technical complications where the third-party service would require to access the user’s physical activity data.

Another approach would be to build a tool that can replace online advertisements on web pages with reminders about the user’s physical activity. This implementation can be done on the client side which means a third-party advertisement service is not needed and that would allow us to have more freedom and control over how and when the users should be reminded. Weighing the two approaches, we opted to develop an extension based on the second approach because we can flexibly control and manage the reminder ourselves, without involving third parties.

To evaluate the usability of FitViz-Ad, we designed a mixed method study by recruiting 14 participants for a 2-week study. It should be noted that this evaluation focused on healthy participants who are not RA patients. We wanted to use this evaluation to try to understand how the users react to the idea of a non-intrusive reminder. Participants were randomly assigned into one of the two groups, control and treatment, where participants in the control group received a stripped down version of FitViz-Ad while participants in the treatment group received a full-functioning version of the extension. The study was split into two phases, baseline and intervention phase. Participants were not given any instructions during the baseline phase where only their everyday baseline data was collected. In the intervention phase, participants were instructed to install FitViz-Ad on their primary machine and were asked to try to achieve 8 non-sedentary hours per day. At the end of the 2-week study, each participant was interviewed about their experience.
The approach and methodology presented in this section will be discussed in detail in Chapter 4, *Evaluation*. We will also discuss the design principles of FitViz-Ad, how it was built, how we evaluated *FitViz-Ad* and the results of the evaluation of this thesis work.

### 1.5 Thesis Overview

In this section, we overview different chapters in this thesis work and the main point of each chapter.

*Chapter 1: Introduction* outlines the growing trend with wearable technologies, the population group that is not the direct beneficiary of the technology, what is rheumatoid arthritis, research question and a brief look at the approach and methodology adopted for this work.

*Chapter 2: Literature Review* outlines relevant research work related to this work. This chapter looks at the impact of physical activity on the quality of life, transtheoretical model of health behaviour change, different techniques in encouraging physical activity, currently available wearable technologies on the market, self-efficacy and goal-setting and the negative perceptions toward online advertisements.

*Chapter 3: Implementation* outlines the design principles behind FitViz-Ad, why and how it was built, the challenges presented throughout the development process and how we overcame those challenges.

*Chapter 4: Evaluation* outlines in details about the evaluation study designed to evaluate the effectiveness of FitViz-Ad in encouraging physical activity.

*Chapter 5: Results* outlines the results of the evaluation and how participants responded based on their experience with FitViz-Ad.
Chapter 6: Discussion analyses the results of the evaluation to answer the main research question in this thesis work. Various shortcomings, insights, design implications and possible future design iterations are discussed in this chapter.

Chapter 7: Conclusion summarizes the thesis work and discusses possible future work with respect to this thesis work.
Chapter 2

Literature Review

In this chapter, we overview related research work that discusses the impacts of physical activity on health, a model for health behaviour change, techniques used to encourage physical activity, currently available wearable technologies, self-efficacy & goal-setting and last but not least, why online advertisements are perceived as annoying.

2.1 Impacts of Physical Activity on Health

It is well known that physical activity can improve one’s physical and mental health. Studies have shown that people can gain a lot of benefits from leading a physically active lifestyle [55]. Chan, Ryan and Tudor-Locke studied the effects of a pedometer-based physical activity intervention on 106 sedentary workers [9]. Participants’ physical activity was compared before and after a 12-week intervention which the authors evaluated changes in body mass index (BMI), waist girth, resting heart rate and blood pressure. Results from the study showed an increase in step count and a decrease in BMI, waist girth and heart rate.

Research has also shown that physical activity can reduce the risk of different diseases have in one’s life. An individual that leads a physically active lifestyle is less likely to suffer from premature mortality [58, 54] and cardiovascular disease [76, 49, 61]. A study
by Knowler et al. used a lifestyle-intervention program and the administration of medications to prevent or delay the development of diabetes [33]. Knowler et al. recruited 3,234 nondiabetic participants who were at high risk for diabetes. Participants were randomly assigned into one of the three interventions: metformin (medication used to improve blood sugar control for type-2 diabetes patients) at 850mg twice a day, placebo twice a day or an intensive lifestyle modification program. The lifestyle intervention required participants to lose at least 7 percent of their weight and at least 150 minutes of physical activity per week. Results from the study showed that the lifestyle intervention reduced the incidence of diabetes by 58 percent and metformin by 31 percent compared with placebo. The authors concluded that physical activity was more effective than metformin in preventing type-2 diabetes. Physical activity is also believed to be an effective mean in preventing lower back pain as well as effective in treatment and rehabilitation of osteoarthritis [85] and has shown to decrease the risk of colon cancer [69], obesity [87] and mental health issues like depression and anxiety [31, 73, 9].

Because physical activity can also be beneficial for people with chronic pain, RA patients can also gain a lot of benefits from leading a physically active lifestyle. However, a lot of them are not physically active due to the pain and discomfort when moving about. Eurenius and colleagues analyzed data on self-reported physical activity, physical fitness, activity performance and disease activity to identify the correlation between physical activity and general health perception [20]. Eurenius et al. collected data from a sample of 298 participants diagnosed with RA. Findings from their study showed that almost half of their sample (47%) did not comply with public health recommendations. It was also revealed that female participants above 65 years of age seemed to be less physically active than either male participants of the same age or younger females. It was speculated that one of the reasons might be that older women with RA were satisfied with an inactive lifestyle that they did not intend to change or not motivated enough to become physically active [20]. This finding also confirmed previous results that showed a decline in both moderate and vigorous leisure-time physical activity among older women [68, 38, 7].
With overwhelming evidence that show positive impacts of physical activity and the lack of physical activity among people with chronic pain, it is important to explore different approaches to encourage RA patients to be more physically active.

2.2 Transtheoretical Model of Health Behaviour Change (TTM)

Lifestyle change can be challenging and intimidating for certain individuals. Some of the challenges might come from an economic point of view including the availability and cost of healthy foods or the cost of a gym membership while other challenges are psychological [36]. However, a lifestyle change can be achieved without causing major disruption to one’s life. People who walked at least 10,000 steps a day were more likely to maintain their desired weight [83]. Understanding one’s desire to commit to a lifestyle change has been a subject of many cognitive and clinical psychology studies. One of the most widely accepted theoretical models for behaviour change was introduced by James Prochaska called Transtheoretical Model (TTM) [63].

Prochaska’s TTM suggests that an individual changes his/her behaviour by going through 6 steps:

1. **Precontemplation**: Individuals in this stage do not intend to take action in the next 6 months. Individuals may be at this stage because they are uninformed about the consequences of their actions or they may have failed to change. They became demoralized about their own abilities to make changes.

2. **Contemplation**: Individuals in this stage intend to take action to change in the next 6 months. At this stage, they are aware of both the pros and cons of changing. Yet, this balance between the pros and cons of changing may produce contradictory ideas that can keep people at this stage for a long period of time. This phenomenon is characterized as *chronic contemplation* or *behavioral procrastination*.
3. *Preparation*: Individual in this stage intend to take action in the immediate future, usually next month. They usually have taken some action for change in the past year. These individuals may also have plans of action for change such as joining the gym and talking to their physician etc.

4. *Action*: Individuals in this stage have lifestyles changed within the past 6 months. Behaviour change is often associated with action, however, action is only one of the six stages of behaviour change in this model.

5. *Maintenance*: Individuals in this stage are in the process of maintaining the change to avoid relapse, however, change processes are not applied as frequently as those in the *action* stage.

6. *Termination*: Individuals in this stage have zero temptations. The changes made are permanent with no chance of relapse. It was noted that termination phase might not be practical in reality for the majority of the people.

In our study conducted for this thesis work, we adapted Prochaska’s Transtheoretical Model to evaluate and compare the stages that participants were in before and at the end of the study.

### 2.3 Different Approaches to Encourage Physical Activity

#### 2.3.1 Encouraging Physical Activity Through Virtual Games

Numerous studies have explored different techniques to encourage people to be physically active. There have been explorations in using computer games to promote physical activity. One of those games was *Fish’n’Steps*, developed by Lin, Mamykina, Lindtner, Delajoux and Strub, which aimed to promote exercise and improve users’ attitude toward physical activity [36]. With a Sportline 330 pedometer, the user’s step count is measured and the cumulative step count is displayed on the pedometer. In order to collect the data from the
pedometer, participants placed the pedometer on at a public kiosk and took a photo of the pedometer screen showing the cumulative step count and the pedometer’s unique ID. The picture was then sent to a member of the research team who entered the captured data into the database.

Once the data was input into the database, the application calculated the change in step count and compare that with the personal goal of each participant. Each participant had his/her personal goal established prior to the commencement of the study for comparison. The daily progress of each participant was then mapped to the growth of a virtual pet fish. The pet fish had a number of pre-defined growth target in which the fish appearance would change when the total number of steps exceeds the pre-defined target. Once the fish had grown to the maximum level, a new additional baby fish was then added to the tank. The baby fish also grew based on the total number of steps of the participants. Each pet fish also had a facial expression which was rendered based on participants’ success in reaching their daily goals. The fish would have a happy expression if the participant achieved his/her daily goal, angry if the participant nearly achieved his/her daily goal and sad if the participant did not achieve his/her daily goal.

Nineteen participants who had sedentary jobs that did not require physical activity were recruited to evaluate Fish’n’Ssteps. The author also adopted Prochaska’s Transtheoretical Model of Behavioural Change (TTM) [63] to understand and assess the behaviour change toward physical activity among the participants. Finding from this study showed that 14 out of 19 participants who completed the study showed advancement in the level of Transtheoretical Model and/or increase in the number of daily steps. Lin et al. found evidence that participants' ability to take advantage of Fish’n’Ssteps largely depended on their physical activity level, their willingness to change, their satisfaction with the artefact as well as the stage they were in with respect to the Transtheoretical Model.

Other studies have focused on how active video games (AVG) can promote physical activity. A study by Lanningham-Foster, Foster, McCrady, Jensen, Mitre and Levine tested a hypothesis that children and adults would burn more calories and be more physically active
while playing activity-promoting video games than sedentary video games [34]. In this study of 42 participants (22 children and 20 adults), their energy expense and physical activity were measured and compared between while they were resting, standing, watching television and playing sedentary video games and while they were playing Nintendo Wii Boxing game. Results from this study showed that participants that played activity-promoting video games (Nintendo Wii Boxing) expended more than twice the amount of energy compared to those that played sedentary video games. The authors also found evidence that sustained engagement with activity-promoting video games is challenging though it can be achieved when children play with others, which agreed with previous studies [44, 10]. There are also multiple systematic reviews of using AVG to promote physical activity [18, 59] which look at various publications regarding AVG and physical activity in order to assess the current state of research and possible future research work. Findings suggest that AVGs have the potential to promote light to moderate amount of physical activity however due to limited evidence, little is known about the long-term efficacy of AVGs for physical activity promotion. As AVGs grows in popularity, Peng et al. stated that additional research is needed to determine how to take advantage of AVGs to promote physical activity and understand its long-term efficacy [59].

2.3.2 Encouraging Physical Activity Through Text Messaging

Multiple studies have investigated if text-messages can be used as an effective reminder in managing chronic diseases, addiction, weight and also physical activity [23, 66, 46, 67, 57, 78]. One of the studies conducted a 12-week randomized controlled trial to evaluate if the use of pedometers and text messaging would increase physical activity among adolescents with type 1 diabetes [52]. Newton et al. reported that the participants’ physical activity did not increase with the use of text-messaging in the study in the 12-week intervention study.

Noticing that many of studies were short-term studies (10 days to 3 weeks) and small sample size, Mutsuddi and Connelly conducted an extended study of a longer term (3
months) with a sample size of 28 participants [12]. The authors underlined the effectiveness of text messages to encourage physical activity among young adults between the age of 18-24. The study intended to understand the long-term effect of text messages in encouraging physical activity. Similar to Lin et al.’s work, Mutsuddi and Connelly adapted TTM to assess the motivational level of participants toward behaviour change. Encouraging text messages were sent to the participants twice a day to get them to walk toward their step goal. The authors prepared 179 different messages which was categorized into 9 categories: reduce barriers, pros and cons, personal testimonies, reward, motivation, information, goal setting, time management/tips and public testimonies. Some of the text messages were: 'Walking can improve ur mood!', 'Nothing will work unless you do. -Maya Angelou' and 'Don’t over stride. It’ll make u tired quickly.' Results from this study showed that text messages are effective in encouraging physical activity in young adults. Its effect sustained even after the novelty effect of the technology wore off. The average step count of the participants increased throughout the intervention period while participants also showed signs of behaviour change.

Like Mutsuddi and Connelly’s approach, we implemented encouraging messages into FitViz-Ad reminders. For instance, the participant is presented with an encouraging message if he/she is only one non-sedentary hour away from completing the daily goal. Participants are also presented with a congratulatory message when they achieve their goals. Encouraging physical activity through messages will be discussed in detail the Implementation chapter.

2.3.3 Encouraging Physical Activity Through Social Connections

Other studies have incorporated the use of pedometers and social connections via mobile apps. Houston is a mobile application that encourages physical activity by sharing step count with friends [13]. Using text messages, users can send their step count and messages to their friends. They can also send a request to see their friends’ step count and progress. The authors recruited 13 participants for a 3-week study which the participants used Houston to
achieve their individual goals. Consolvo et al. initiated individual goals for the participants by getting participants to record their daily step count every day for one week. The highest step count was rounded to the next thousand and used as a daily goal for the duration of the study. Findings from the study suggested that while participants were personally aware of their physical activity which was effective in increasing their physical activity, the social support they got from their friends was also a factor in the step count increase. Consolvo et al. found that the combination of personal awareness and social support seemed to be the most effective especially when participants received motivating text messages or praises from their peers.

Similarly, another mobile application called Chick Clique developed by Tosco, Faber, An and Gandhi from Indiana University used social connections to encourage teenage girls to exercise [77]. Tosco et al. stated that they wanted to exploit teenage girls’ desire to stay connected within their social circle and use that to encourage them to be physically active. Chick Clique was intended for teenage girls from age 12 to 19 because they are more likely to be less physically active compared to their male counterparts during adolescence [51]. It was also reported that teenage girls are more likely to use dangerous and unhealthy methods to lose weight including skipping meals or purging [84]. Tosco et al. recruited seven high school students separated into two groups of friends to evaluate Chick Clique for four days. It was revealed that the participants were more aware of the relationship between food, exercise and health. Participants also noted that the platform allowed them to be more open to each other regarding their health-related issues. The team later conducted a longer study (3 weeks) to give a more detailed evaluation of using text messages among social peers to encourage physical activity [79]. The extended study showed that participants in a group lost interest when one of them did not actively engage with the group. It was also revealed that participants tend to struggle with what to say to each other which they only congratulated each other "Good job!" if anyone was physically active. This suggests that text messages might not be very effective unless they are substantial in how participants communicate with each other.
Mixed results from Houston and Chick Clique prompted for research and design considerations for better understanding of how text messages and social connections can be implemented into technology for physical activity encouragement. For example, certain design choices can be made to sustain participants’ interest in the tool. The tool can actively propose a new topic of conversation for participants to share thoughts and strategy for physical activity.

2.4 Wearable Technologies for Monitoring Physical Activity

As mentioned earlier in the introduction of this thesis work, wearable devices like Fitbit, Nike+ FuelBand, Garmin and Jawbone etc are on the rise. These commercial pedometers are usually on-body devices that include multiple sensors to collect various parameters including physical activity and sleep pattern. Their tracking capabilities are usually either through GPS tracking or built-in accelerometer. With these devices, users can access their data either on smartphones(Figure 2.1) or web applications(Figure 2.2) in which the users can view their own data through different visualizations.

Pedometers have been widely used in various study settings mainly physical activity related studies [82, 4, 52, 9, 77, 15, 12, 36]. For instance, Bravata and her colleagues published a systematic review of using pedometers to increase physical activity and improve health [4]. Bravata et al. concluded from the study that there was an association between the use of pedometers and the significant increase in physical activity and decrease in body mass index and blood pressure. Pedometers are also used as an intervention for encouraging physical activity. The procedure of a pedometer intervention usually involves giving the participants pedometers to wear every day for a set period of time. One of the studies that used pedometers as an intervention was by Catrine Tudor-Locke in which the author stated that "pedometers are practical, accurate and acceptable tools for measurement and motivation in physical activity" [82]. Tudor-Locke also noted that even though the universal goal of 10,000 steps/day seems to be widely accepted, such goal should be approached with
Figure 2.1: Apple Health app visualizing user’s collected data
http://i0.kym-cdn.com/photos/images/original/001/006/842/dd5.jpg

Figure 2.2: Fitbit’s web-based dashboard
https://thehealthystruggleblog.files.wordpress.com/2016/04/desktop.png?w=530
caution. The author suggested a better approach in which one’s baseline values, specific health goals and sustainability of the goal in one’s everyday lifestyle should be considered to personalize one’s step goals.

We share Tudor-Locke’s concern in which we believe that 10,000 steps might not be suitable for everyone especially people with chronic pain like RA patients. Thus, we explored a different approach in how we analysed participants’ physical activity level and we set out FitViz-Ad to have custom goals that would be more appropriate for certain individuals.

2.5 Self-Efficacy & Goal-Setting

When it comes to encouraging physical activity, self-efficacy and goal-setting have been the focal points in many studies. Enjoyment of exercise, social support, self-efficacy and autonomous motivation are shown to project higher physical activity [80]. So what is self-efficacy? And what impact does it have on one’s motivation for physical activity? Self-efficacy is one’s belief in his or her own capabilities in performing a specific behaviour [3]. Similar to the general public, it was also revealed that self-efficacy predicts higher physical activity among RA patients [43]. This suggests that the belief that one has in his/her capabilities plays a significant role in how one can be motivated to be physically active, hence self-efficacy can also predict one’s ability to go through health behaviour change as outlined by Prochaska’s TTM. Various interventions were developed to increase self-efficacy for physical activity. These interventions usually involve encouraging patients to set their personal physical goals with plans on how they can achieve their goals [37].

In a study by Knittle, De Gucht, Hurkmans, Vliet Vlieland, Peeters, Ronday and Maes, it was suggested that the idea behind goal-setting interventions was to allow patients to have a realistic goal to achieve. They believed that the more realistic the goal is to achieve, the more likely it is to achieve the goal which in turns improve self-efficacy among patients to be more physically active [32]. To understand the effect and relationship of self-efficacy and physical activity among arthritis patients, Knittle et al. conducted a survey study of
643 randomly selected participants with rheumatoid arthritis from three hospitals in The Netherlands. Participants were asked to complete a baseline questionnaire regarding their physical activity goals, motivation, self-efficacy for physical activity, pain and discomfort from arthritis and their quality of life. 271 out of the 643 participants responded and the results suggested that patients who were physically active tend to value themselves as competent to remain physically active and vice versa. They also noted that there was a 'positive relationship between self-efficacy at baseline and subsequent achievement of physical activity goals'. This suggests that the patient’s belief in him/herself in performing a specific behaviour can be driven by their physical activity achievements.

Similar to self-efficacy, numerous studies investigated the use of goal-setting to encourage physical activity. Consolvo et al. studied individual’s responses to goal-setting in their persuasive technologies to encourage physical activity [14]. In their study, they explored individual’s reactions to goal sources (i.e., who should set the goal) and goal timeframes (i.e., the timeframe that an individual needs to achieve the goal). They reported that most participants would prefer to set their own goals. Consolvo et al. also implemented goal-setting into their UbiFit which required participants to set their own weekly physical activity goal [15]. Similarly, Zuckerman and Gal-Oz asked their participants to set up their own activity goals in terms of active minutes [90]. These implementations suggested that goal-setting can motivate individuals to be physically active. Bravata et al. also argued that setting a step goal was a significant motivator for increasing physical activity [4].

On the other hand, it is important to consider how goal-setting can be exploited. Allowing the users to freely set their own goals can be dangerous [40, 39] because individuals can make false inferences based on the data collected. For instance, an RA patient might risk getting an injury by increase his/her physical activity goal without consulting a professional because he/she is confident in achieving the goal.

Conforming with these findings, we incorporated goal-setting into FitViz-Ad by allowing doctors to set the goals for the patients. Should they wish to change their activity goal, doctors or clinicians should be consulted before they can do so. With this approach, we
hope to give patients with realistic goals that they can achieve within the scope of what
the doctor recommends. By achieving their goals, patients can feel more confident in their
ability to be physically active.

2.6 Why Online Advertisements are Annoying

Online advertisements are used to gain user’s attention with the purpose of selling a prod-
uct or a service (Figure 2.3). However, there are numerous negative impacts when online
advertisements are distracting or annoying. Annoying ads may backfire and cause users to
distance themselves from the advertiser’s brand or doubt its reputation. Marketing research
by Yoo and Kim suggested that users are less likely to remember highly annoying ads [89]
and actively ignored stimuli like annoying ads are evaluated less favourably [72]. With many
users perceive online advertisements as annoying, it might increase the use of ad-blocking
software [17, 35] like Ad-Block extension which has more than 100 million active devices
using the extension ¹.

Goldstein and colleagues conducted three empirical studies to investigate the economic
cost of annoying ads to publishers and the cognitive impact of annoying ads to users [24].
The authors first conducted a preliminary study to identify ads that the users find more or
less annoying, then they conducted a field experiment to find out the amount of money the
publishers pay for advertisements. Lastly, the authors conducted a mouse-tracking study
to understand the effects of online advertisements on the reading processes. Results showed
that annoying ads increased task completion time which also led to slightly lower accuracy
on reading comprehension questions. It was also shown that users tend to notice annoying
ads and complain about them and they are also more likely to abandon the sites with
annoying ads.

¹See https://adblockplus.org/
2.7 Discussion

In this section of the chapter, we discuss related work and how it can shape our understanding and design intentions for FitViz-Ad. We will look at why it is important for RA patients to have an appropriate tool that can help remind them to be physically active, especially for those who hold sedentary jobs. We will also discuss key aspects of how designing artefact for RA patients different from other designs intended for the general usage as well as the potential opportunities and challenges that come with this research work.

2.7.1 Motivating RA Patients

Having overviewed previous research studies, it is evident why physical activity is recommended for the general public and also RA patients. Furthermore, motivation is another important aspect for RA patients to stay physically active. RA patients should be encouraged and motivated to be physically active to overcome the pain and discomfort so they are confident in successfully leading a physically active lifestyle. When designing a tool
to motivate people to perform certain tasks they cannot derive pleasure from immediately, we need to carefully consider slowly easing them into the desired behaviour. Activity goal recommendations that are unrealistic may backfire and cause negative perception toward the tool. We also need to make sure that the tool needs to accommodate with the patients’ daily life as we do not want the tool to interfere with their lives so much that they feel annoyed and end up abandoning the tool.

2.7.2 Opportunities & Challenges

Negative perceptions that the users have toward online advertisements provide us with new opportunities to transform the space that people do not appreciate to something that contains relevant personal information that provides awareness and knowledge. We can look at this as converting a negative virtual space to a positive one. This concept can be seen as a novel idea that we can use to appeal to RA patients so they might be interested in using the tool and we hope that their interest in the tool can sustain once they have adapted to a physically active lifestyle. Furthermore, we intend to provide RA patients with a tool that overrides those default settings set by commercial products and customize the tools to be suitable for RA patients. We will discuss the design intentions in more detail in the next chapter.

Moreover, we noticed that a lot of commercial products quantify physical activities into step count. Although step count can be useful and easy to provide the users with a way to quantify their physical activities, it might not be appropriate for those who struggle with physical activities like RA patients. For example, completing 10,000 steps a day is recommended for the general public however it does not account for the time spent on doing physical activities. This step count can be in a time span of 2 hours when the user is playing sports or exercising. The recommended step count can be achieved by cramming physical activity into a short intense segment. However, it is very difficult and intimidating for RA patients to perform intense physical activities. Thus, we intended to come up with another unit to quantify their physical activity, one that encourages them to be physically active...
throughout the day. For FitViz-Ad, non-sedentary hour is used to quantify user’s physical activity. The non-sedentary unit was designed to take into considerations of the time spent on the actual physical activity and the time spent while staying sedentary. We believe that non-sedentary hour allows FitViz-Ad to remind RA patients and pace their physical activities throughout the day. The design principle and technicality of non-sedentary hour unit will be discussed in the following chapter.

Having said that, we must acknowledge the challenges that came with these opportunities in designing the tool. Because of the novelty of the tool, it might not be as effective in reminding RA patients to be physically active as we intended. They might prefer traditional pop-ups as reminders instead of having the content of the web pages modified. On top of this, providing motivation can also be a potential challenge in the attempt to make sure that users’ interest in the tool can sustain for a long period of time. Participants might not find messages shown on FitViz-Ad to be as encouraging as we intended it to be and would lose interest in the tool.
Chapter 3

Implementation

In this section of the paper, we discuss the design and implementation of FitViz-Ad which introduces its features and how those can be beneficial to RA patients. We then go into detail regarding the technical implementations and challenges in the development FitViz-Ad. In the current version of FitViz-Ad, FitViz-Ad is a Chrome browser extension exclusively that is currently on the Chrome Web Store through private invites only.

3.1 Design Principle

Before we started to implement FitViz-Ad, we conceptualized a number of ways to remind users about their physical activity. In order to remind the user when they should get up and walk, we needed to think about the platforms that can be used to notify the user. One possible approach would be to use the Fitbit tracker as a notification device where the tracker can vibrate and notify the user to get up and walk. However, as of writing this, there is no possible way to send an alert via Fitbit API to the Fitbit tracker. Smartphones is another platform that we can push reminders to the users however it requires the users to carry their phones around at all times. Moreover, because we are interested in targeting
people who spend most of their time in front of computers, having an extra device involved is not preferred.

Another approach would be to generate a notification reminder on the computer that would alert the users to get up and walk. However, notifications can be very disruptive and may be distracting for the users who try to complete a certain task [27], as stated earlier in this thesis. Thus, we needed to come up with a non-intrusive alternative.

3.1.1 Becoming an Advertisement

From the beginning of FitViz-Ad development, we have been interested in developing an artefact to encourage physical activity without causing major disruption to the user’s current lifestyle. Chris Shaw came up with the idea of replacing online advertisements on websites that the user find annoying or irrelevant with information about the user’s physical activity instead. It is understood that people dislike online advertisements which are distracting when they surf the web [25, 24]. FitViz-Ad’s idea is to convert the space that the users negatively associate online advertisements with to informative space that provide the users with knowledge and personal awareness regarding their physical activity.

It is also shown that online advertising is effective in engaging the user with the media context especially with personalized context about a specific user[5]. Unlike system generated notifications that use audio and/or visual elements to get the user’s attention, FitViz-Ad silently replaces online advertisements on the page that the user is visiting with reminders about the user’s current physical activity level. With this, we hope that the users’ daily tasks would not be disrupted and they would not feel that physical activities are daily chores that they need to be constantly reminded to do.

To make use of the existing online advertisement spaces, FitViz-Ad could either be an actual online advertisement that is placed onto web pages by third-party online advertisement companies or it could operate on the client-side and locally manipulate web pages that the users visit. The primary drawback of the first approach is that it requires a third-party
ad company. We decided to use the local replacement approach because it is free and it allows us to have greater control of dynamic information tailored specifically for the user. Another advantage is that it directly requires the user’s consent, which is valuable given the medical context of the work. We achieved this by implementing FitViz-Ad as a browser extension which is capable of gathering data and manipulating web pages on the user’s local machine.

3.1.2 Non-Sedentary Hour Unit

FitViz-Ad was developed as a non-intrusive personal reminder system to encourage rheumatoid arthritis patients to complete their daily activity goals. A daily goal is prescribed for patients by clinicians or doctors in a form of ‘non-sedentary hour’. A clinician or doctor, together with their patient, defines how many minutes in an hour that a patient should spend moving about. A given hour is non-sedentary when at least $N$ minutes of an hour contain more than 10 steps. The threshold of 10 steps was established to ignore minutes where Fitbit may potentially capture false steps [53].

3.1.3 Transforming Online Ad Spaces & Daily Milestones

Since most Internet users have a negative attitude toward repetitive online advertisements [6, 45, 86], we decided to transform the online advertisement space into a space that contains relevant information that would be personalized to the user. FitViz-Ad reminds RA patients when they should be physically active by replacing online advertisements on the webpage with reminders about the patient’s progress toward completing his/her non-sedentary goal (Figure 3.1).

FitViz-Ad can potentially remind the patients up to 5 times a day, starting from 10 AM to 10 PM with a 3-hour interval between each reminder (10 AM, 1 PM, 4 PM, 7 PM and 10 PM). The non-sedentary daily goal prescribed by the doctor is divided by 5 to compute the milestone for each segment. For example, if the patient is prescribed to complete 10 non-
sedentary hours per day, FitViz-Ad would then remind the patient to have 2 non-sedentary hours completed by 10 AM. On the reminder, there is an image of the patient’s personal doctor or clinician to provide a personal touch in which the patient can feel assured that his/her progress is monitored by the same clinician or doctor that follow their condition.

![figure 3.1](image)

Figure 3.1: FitViz-Ad’s reminder that replaces online ads on webpages. The reminder on the left is generated when the user is behind the non-sedentary goal milestone while the right one is generated when the user’s non-sedentary goal is achieved.

### 3.2 Technical Implementation

*FitViz-Ad* is an extension that was built on its parent app called “*FitViz Web App*”, which is a web application that uses the Fitbit API to gather user’s physical activity data and present a different form of activity visualization purposely built for people with RA. FitViz web application keeps records of the user profiles, Fitbit data and the non-sedentary hour requirement for each user (Figure 3.3).

To avoid confusion, we are going to refer to *FitViz-Ad* as 'the extension' in this section. The extension works by making a request through *FitViz Web API* for the user’s physical
Figure 3.2: FitViz-Ad works in conjunction with its parent app, FitViz Web App, to get user’s Fitbit data and necessary settings including the non-sedentary hour goal.

Figure 3.3: FitViz-Ad works in conjunction with its parent app, FitViz Web App, to get user’s Fitbit data and necessary settings including the non-sedentary hour goal.

activity data, and FitViz Web App returns the information requested back to the extension for HTML DOM manipulation (Figure 3.2). When the user launches the extension, a Fitbit OAuth window would appear prompting the user to input his/her Fitbit’s credential. This authentication process is made through the FitViz-Web App and through its API. The extension automatically makes requests for the user’s non-sedentary hour progress and the daily non-sedentary goal for that specific user. FitViz Web App is responsible for collecting data in the form of step count and computing the equivalent non-sedentary hour based on the step count before returning the computed non-sedentary hour data to the extension.
The extension automatically requests data from the FitViz Web App every 15 minutes in the background while the browser is running. The extension has five pre-set times that it would generate reminders on the web pages, which we will further discuss in the next section. When one of the five pre-set times is reached, the extension uses a Javascript file that is executed in the context of the currently active web page called “Content Script”. Content Script manipulates the currently active web page to replace existing online advertisements on the web page with pop up reminders generated by the extension.

3.3 Reminder From a Personal Doctor

To add a more personal touch to the reminder, FitViz-Ad includes an image of the user’s personal doctor in the reminder (Figure 3.1). We hope that this would establish the credibility of the physical activity progress shown on the reminder and the user would be more inclined to get up to walk around knowing that the reminder is from their personal doctor. In the case of the study presented in this thesis where participants did not have a personal doctor or clinician, a stock image of a doctor\(^1\) was used instead. The user can see the non-sedentary progress that he/she has completed and the goal that needed to be achieved at any time by clicking on the FitViz-Ad extension (Figure 3.4).

3.4 Non-Intrusive Reminder

When the user’s local time reaches one of the preset reminder times, FitViz-Ad checks and compares the current non-sedentary hour completed and the milestone that is required for that segment. FitViz-Ad generates a reminder on the webpage based on 4 different scenarios (Table 3.1) and the user will see different messages on the reminders based on the user’s non-sedentary hour progress:

\(^1\)Image from https://i.pinimg.com/236x/d6/93/2e/d6932ee213a513a6c5c1456b4dd1b3d.jpg
Figure 3.4: Clicking on the extension on Chrome displays the progress that the user has made for the current day and the user’s daily goal. The 2 circles at the bottom of the dialog represent the completed non-sedentary hour (on hover, they show the exact hour that the patient was non-sedentary).

1. If the user’s current non-sedentary hour is lower than the computed milestone. For instance, if at 10 AM the user has not completed any non-sedentary hours, FitViz-Ad would generate a reminder to remind the user that the user should have had completed 2 non-sedentary hours by 10 AM, the user now should try to compensate the missing non-sedentary hours by the next milestone. The message shown on the reminder: “You’re behind your daily non-sedentary hour goal”.

2. If the user’s non-sedentary hour is 3 hours more than the prescribed non-sedentary hour goal, meaning that the patient has completed more non-sedentary hour than the prescribed limit. The message shown on the reminder: “You’ve gone over your goal today! You shouldn’t complete more non-sedentary hours than what your doctor prescribed”.

31
Table 3.1: This table shows different messages that are displayed to users to remind them about their non-sedentary hour progress. Each scenario would generate a different message.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>If the user’s current non-sedentary hour is lower than the required milestone for non-sedentary goal</td>
<td>You’re behind your daily non-sedentary hour goal</td>
</tr>
<tr>
<td>If the user’s non-sedentary hour is higher than non-sedentary goal.</td>
<td>You’ve gone over your goal today! You shouldn’t complete more non-sedentary hours than what your doctor prescribed.</td>
</tr>
<tr>
<td>If the user has achieved his/her non-sedentary goal.</td>
<td>CONGRATULATIONS! You have completed your non-sedentary goal for today!</td>
</tr>
<tr>
<td>If the user is 1 hour away from completing his/her non-sedentary goal.</td>
<td>You’re almost there! Only 1 hour left to be completed to achieve your non-sedentary daily goal!</td>
</tr>
</tbody>
</table>

3. If the user has achieved his/her non-sedentary goal. FitViz-Ad would generate a congratulation message to the user and inform the user that he/she has completed the required non-sedentary goal. We hope that the message can motivate patients to maintain their achievements in the long run. The message shown on the reminder: “CONGRATULATIONS! You have completed your non-sedentary goal for today!”

4. If the user is only one hour short of completing his/her non-sedentary goal while there are only 3 hours remaining in the day. FitViz-Ad would generate an encouragement message informing the patient that there is only one more to be completed. The message shown on the reminder: “You’re almost there! Only 1 hour left to be completed to achieve your non-sedentary daily goal!”

Through the development of FitViz-Ad, we were interested in building a tool that would keep the distraction level to the minimum. The idea of one being reminded five times a day on a daily basis can be excessive, so different measures were implemented to ensure that FitViz-Ad would not distract the users from their daily activities when it is not necessary. The extension would not generate reminders on the following conditions:
1. If the user’s non-sedentary hour is equal or more than the computed milestone that is required for that segment. For example, if the user’s non-sedentary goal is 10 hours and by 1 PM the user has completed 4 non-sedentary hours, FitViz-Ad does not generate a reminder because the user is on track to completing his/her 10 non-sedentary hour goal.

2. If user’s non-sedentary hour is far lower than the non-sedentary goal and it is not possible for the patient to catch up. For example, if the user’s non-sedentary goal is 10 hours and by 7 PM the user has only completed 3 non-sedentary hours, FitViz-Ad would not remind the user because it is not possible for the user to catch up given the fact there are only 5 hours remaining on that day and there are still 7 more non-sedentary hours to be completed.

3.5 Replacing Online Advertisements

FitViz-Ad can identify third-party advertisements like Google AdSense on different web pages and copy the size of those advertisements. FitViz-Ad then generates reminders using the copied dimensions. Existing advertisements are then removed and replaced by the generated reminders (Figure 3.5). This implementation is in place to ensure that the reminder takes up the same amount of space as the original advertisement. This prevents unintentional shifting of the content of the page by making sure that the reminder is the exact same size as the original advertisement that it replaces. FitViz-Ad executes this process without reloading the webpage which avoids interfering with the user’s current task.

FitViz-Ad can also identify advertisements that are shown on popular websites including Facebook, YouTube, StackOverflow and Amazon.ca/.com etc. Some of these websites have their own business programs where they self-manage online advertisements on their websites [21, 70]. For those websites, we have predefined the location of the advertisement spaces because each website used different identifiers for their advertisement spaces. Using the predefined locations, FitViz-Ad targets the contents of those locations and replace them
Figure 3.5: FitViz-Ad replaces an advertisement on the page with a reminder by copying its dimension.

with reminders(Figure 3.6). If FitViz-Ad cannot identify or find any ads on the webpage, it would generate a small reminder and place it on the top right corner of the webpage that the user is on (Figure 3.7).
Figure 3.6: FitViz-Ad places a reminder on the user’s Facebook page. The reminder replaces the advertisements or pages that Facebook tend to suggest to the user.

Figure 3.7: FitViz-Ad places a reminder on the user’s Facebook page. The reminder replaces the advertisements or pages that Facebook tend to suggest to the user.
Chapter 4

Evaluation

We conducted a 2-week usability study in Summer 2017 to evaluate the effectiveness of FitViz-Ad in encouraging physical activity. In this section, we discuss the procedure of the study, participants that we recruited for the study, limitations and challenges that we faced and how we collected and analyzed the data.

4.1 Participants

We recruited 14 participants (7 males and 7 females) using a snowball sampling technique where we shared our study advertisement with contacts across a number of social media platforms (e.g., Facebook and LinkedIn). Participants recruited ranged between the age of 20 and 37. In this study, we’d refer to our participants as P1, P2, P3 and so on to protect their identities. We diversified our participants by recruiting undergraduate students, graduate students and people who hold full-time positions. Two participants were graduate students in either a Masters or PhD program, three were undergraduate students, seven were full-time employees who have sedentary jobs and two preferred not to disclose information about their occupations (Table 4.1). Each participant received 20 CAD as compensation for their participation in this study.
Table 4.1: Information about participants including their age, gender and occupation

<table>
<thead>
<tr>
<th>Participant</th>
<th>Age</th>
<th>Gender</th>
<th>Occupation</th>
</tr>
</thead>
<tbody>
<tr>
<td>P01</td>
<td>20</td>
<td>Male</td>
<td>Undergraduate Student</td>
</tr>
<tr>
<td>P02</td>
<td>32</td>
<td>Male</td>
<td>Professional</td>
</tr>
<tr>
<td>P03</td>
<td>30</td>
<td>Female</td>
<td>Professional</td>
</tr>
<tr>
<td>P04</td>
<td>26</td>
<td>Male</td>
<td>Professional</td>
</tr>
<tr>
<td>P05</td>
<td>26</td>
<td>Female</td>
<td>Graduate Student</td>
</tr>
<tr>
<td>P06</td>
<td>25</td>
<td>Female</td>
<td>Professional</td>
</tr>
<tr>
<td>P07</td>
<td>27</td>
<td>Male</td>
<td>Undisclosed</td>
</tr>
<tr>
<td>P08</td>
<td>26</td>
<td>Male</td>
<td>Undergraduate Student</td>
</tr>
<tr>
<td>P09</td>
<td>29</td>
<td>Female</td>
<td>Professional</td>
</tr>
<tr>
<td>P10</td>
<td>26</td>
<td>Male</td>
<td>Professional</td>
</tr>
<tr>
<td>P11</td>
<td>35</td>
<td>Female</td>
<td>Graduate Student</td>
</tr>
<tr>
<td>P12</td>
<td>37</td>
<td>Male</td>
<td>Professional</td>
</tr>
<tr>
<td>P13</td>
<td>21</td>
<td>Female</td>
<td>Undergraduate Student</td>
</tr>
<tr>
<td>P14</td>
<td>28</td>
<td>Female</td>
<td>Undisclosed</td>
</tr>
</tbody>
</table>
4.2 Limitation

Due to limited resources, we opted to conduct a 2-week usability study with healthy participants who do not have RA. Because the concept of using non-intrusive reminders by replacing ads on websites is a fairly new idea and not tested, we wanted to use this early evaluation to understand how the general users feel about this non-intrusive reminder concept. We believe that this evaluation can provide us with a foundation to improve FitViz-Ad before future clinical studies with RA patients.

We need to note that because we do not have data about the participants’ general internet usage, we do not know how many reminders participants see each day and the effects it might have had on the study. However, participants were asked about the time that they usually spend in front of their computers each day and things they usually do when they are on their computers (Table 4.2). All of them reported spending a majority of their time on the internet doing work/school related tasks, reading articles, streaming music or videos and using social media. With this information, we can speculate that the participants spent the majority of their time on the internet and they were likely to see the reminders. Currently, FitViz-Ad is only for Chrome browser and does not work on mobile browsers. At this stage of the development, we are keen on targeting those who have sedentary jobs and spend the majority of their time in front of computers.

We were also not able to provide each participant with a 1-on-1 consultation with a trained physician to establish a recommended non-sedentary hour goal for each participant at the beginning of the study due to the limited amount of time we had. To overcome this, we worked with trained physicians from Arthritis Research Canada to establish a general-purpose 8-hour non-sedentary as an appropriate goal for the healthy participants who do not have any physical restrictions. An hour can be counted as a non-sedentary hour when the participant completes 8+ minutes of walking with each minute consisting of 10 or more steps. This 8+ minutes baseline was put in place by adding the number of minutes (2 minutes) we would like the participants to walk in an hour with a 6-minute error.
buffer. The 6-minute error buffer was established to counteract with the error that Fitbit misclassifies other activities as walking minutes [53].

4.3 Procedure

Before the recruitment process began, interested participants were asked to fill out an online questionnaire asking them basic information about their names, age, occupation etc. They were also asked about their physical activity level and if they have used or currently own a Fitbit tracker. We used the information gathered through this questionnaire to select and diversify our sample.
Table 4.3: Scoring for stages of change

<table>
<thead>
<tr>
<th>Stage</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-contemplation:</td>
<td>No</td>
<td>No</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Contemplation:</td>
<td>No</td>
<td>Yes</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Preparation:</td>
<td>Yes</td>
<td>N/A</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>Action:</td>
<td>Yes</td>
<td>N/A</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Maintenance:</td>
<td>Yes</td>
<td>N/A</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

They were also asked a series of questions to determine their readiness for change in physical activity. Adapted from Prochaska’s TTM, we asked participants a set of questions [41] about their physical activity level before the start the study and at the end of the study.

1. I am currently physically active.
2. I intend to become more physically active in the next six months.
3. I currently engage in regular physical activity.
4. I have been regularly physically active for the past 6 months.

Participants were asked to answer 'Yes' or 'No' to these four statements and scored based on their responses (Table 4.3).

Participants who did not own a Fitbit tracker were provided with a Fitbit Flex for the study. They were given an extra week prior to the study to allow them to familiarize themselves with the Fitbit tracker. During this extra week, they were told to use the Fitbit tracker however they liked and use this week to familiarize themselves with how Fitbit works. Each participant was then randomly assigned to one of the two groups, control group and treatment group (Table 4.4).
Table 4.4: This table shows participants and their assigned group as well as if they own a Fitbit device.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Own Fitbit</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>P01</td>
<td>No</td>
<td>Control Group</td>
</tr>
<tr>
<td>P02</td>
<td>No</td>
<td>Treatment Group</td>
</tr>
<tr>
<td>P03</td>
<td>No</td>
<td>Treatment Group</td>
</tr>
<tr>
<td>P04</td>
<td>Yes</td>
<td>Treatment Group</td>
</tr>
<tr>
<td>P05</td>
<td>Yes</td>
<td>Control Group</td>
</tr>
<tr>
<td>P06</td>
<td>Yes</td>
<td>Treatment Group</td>
</tr>
<tr>
<td>P07</td>
<td>No</td>
<td>Treatment Group</td>
</tr>
<tr>
<td>P08</td>
<td>No</td>
<td>Control Group</td>
</tr>
<tr>
<td>P09</td>
<td>No</td>
<td>Control Group</td>
</tr>
<tr>
<td>P10</td>
<td>No</td>
<td>Treatment Group</td>
</tr>
<tr>
<td>P11</td>
<td>Yes</td>
<td>Control Group</td>
</tr>
<tr>
<td>P12</td>
<td>Yes</td>
<td>Control Group</td>
</tr>
<tr>
<td>P13</td>
<td>No</td>
<td>Treatment Group</td>
</tr>
<tr>
<td>P14</td>
<td>No</td>
<td>Treatment Group</td>
</tr>
</tbody>
</table>

- **Control Group**: received a stripped down version of FitViz-Ad which does not replace ads on websites with reminders. Participants can only check their non-sedentary hour progress and the daily goal by clicking on the extension.

- **Treatment Group**: received a fully functioning version of FitViz-Ad with reminders that replace ads on the websites that they visit. Participants can also click on the extension to see their non-sedentary hour progress and daily goal.

Each group participated in a 2-week study period. The study was divided into two separate phases. We later compared data collected during the two phases.

1. **Baseline Phase**: the first week of the study in which the participants were instructed to only use Fitbit to track their physical activity without using the FitViz-Ad extension.
2. *Intervention Phase:* the second week of the study in which the participants were instructed to install and use FitViz-Ad extension on their primary computer whether it’s a work machine, home machine or both.

During these two phases, there were no specific instructions or tasks given to the participants. They were free to go about their usual daily activities and do whatever tasks they normally do. They were only told to try to achieve their non-sedentary hour daily goal of 8 hours.

### 4.4 Data Collection and Analysis

Quantitative data was collected through the Fitbit in which data from the intervention phase was used to compare with the data from the baseline phase. We also performed various statistical analysis for both completed step count and non-sedentary hour data.

Qualitative data was also collected for this study through post-study semi-structured interviews. After completing the 2-week study, each participant was scheduled a semi-structured interview separately. Each interview was between 30-45 minutes long and participants could opt for an in-person interview or a remote interview via Skype. Due to complicated schedules, two participants opted for remote Skype interviews while the rest had in-person interviews.
Chapter 5

Results

In this section, we present results from both the qualitative and quantitative side. While the qualitative data is reported from all 14 participants, the quantitative data is reported from 12 of the 14 participants, however. Two of the fourteen participants (from the treatment group) had a majority of their data missing from the baseline phase (more than 4 days of missing data) because the participants either forgot to wear their Fitbit trackers or the trackers ran out of battery without them knowing. P03 had 4 days of data missing from the baseline phase and 1 day of missing data from the intervention phase while P04 has 7 days of missing data from the baseline phase and 2 days of missing data from the intervention phase.

Five other participants (three from the control group) had one day of their data missing from the baseline phase because they forgot to wear their Fitbit trackers and/or their trackers ran out of battery. For these five participants, we presented their data of 6 days from the baseline phase and 7 days from the intervention phase. Even with one day of missing data in the baseline phase from the five participants, we are confident that the reported results are reflective of the participants’ physical activity level during the study. Thus, the quantitative results that are reported in this paper account for the 12 participants who completed the study.
5.1 Effects on Physical Activity

Overall, participants had mixed responses to the effectiveness of FitViz-Ad in encouraging physical activity. The majority of the participants between the two groups felt that their physical activity level did not change during the week in which they were using the extension. 6 participants explicitly stated that their physical activity level remained about the same and they did not feel encouraged to be more physically active than usual.

"Not more so than usual. I mean I have my daily goals anyways that I try to get but I didn't feel anymore encouraged." - P05, graduate student, control group

"Not much. Like for instance, it felt like it was more forced. Like for instance, I would have to force myself to try to exercise, and at that point, I would probably end up exercising not as much as the first week. But I mean like, it might just be because like it was appearing a lot as well." - P04, full-time professional, treatment group

Two participants, however, stated that they found the extension to be a useful and motivational tool for them to be physically active. They felt that their physical activity level increased while they were using the extension or at least felt more encouraged to be more physically active.

"Yes, I was more motivated to walk. My physical activity remained the same but like when I was... I usually work 2-3 hours then move a lot, at least in those hours I could move a little bit so I liked that." - P02, full-time professional, treatment group
Figure 5.1: Comparison of the average completed non-sedentary hour between the baseline and intervention phase among the 12 participants.

Through the data collected via the Fitbit trackers, we compared the mean non-sedentary hour completed by the participants during the baseline and the intervention phase (Figure 5.1). Seven participants (four participants from the control group) saw an increase in their non-sedentary hour, however, five other participants (two participants from the control group) saw a decrease. We hypothesized that participants in the treatment group are more physically active than those in the control group. To test this hypothesis, we analysed both the non-sedentary hour and step count data collected from the participants.

5.1.1 Non-Sedentary Hour Data

The average participants’ completed non-sedentary hour ranged from 1.28 to 6.57 hours ($M = 5.16, SD = 1.41$). Non-sedentary hour was non-normally distributed, with skewness of -2.04, kurtosis of 5.13 and standard error mean of 0.4 (Figure 5.2). We then performed a Wilcoxon test which showed no significant difference in non-sedentary hour between the two groups with $W(1) = 32.5, Z = -0.965, p = 0.295$ (Figure 5.3).
Figure 5.2: Normality test shows that the average completed non-sedentary hour data among the 12 participants is not normally distributed

Figure 5.3: A Wilcoxon test shows no significant difference in non-sedentary hour between the control and treatment group
Figure 5.4: Normality test shows that the average completed step count data among the 12 participants is normally distributed

### 5.1.2 Step Count Data

The average participants’ completed step count ranged from 3172.71 to 9887.14 steps ($M = 7067.2$, $SD = 2123.65$). Step count was normally distributed, with skewness of -0.63, kurtosis of -0.2 and standard error mean of 613.04 (Figure 5.4). We then performed a paired-sample t-test to compare the average completed step count between the control and treatment group. There was no significant difference in the average step count for the control group ($M = 7508.93$, $SD = 2423.88$) and treatment group ($M = 6625.48$, $SD = 1891.63$); $t(10) = -0.7$, $p = 0.5$ (Figure 5.5).

Results from the analysis of both the non-sedentary hour and step count data show that participants in the treatment group were not significantly more physically active than those in the control group.
5.2 Physical Activity Awareness

Through the post-study interviews, we also learned that participants felt that the extension provided them with self-awareness regarding their physical activity level even though their physical activity level did not change significantly. Four participants stated that they found themselves more aware of their own physical activity level throughout the day. Among the four participants, 3 were in the control group and one in the treatment group. All of them reported that the extension (either the full version or the stripped down version), they were more aware of their physical activity level during the day. Thus, they had a better understanding of how active they are during their workdays.

"[...] I think awareness was a good one. Without the tool, so when I was just going about my day, when I don’t look at the Fitbit notification cause I shut it off, that tells me I walk 250 steps an hour like I’m not aware of how I’m not
moving at all. But when I started using the app [extension] and I was working, like it was reminding me on a constant basis that I’m not moving. So I knew... like I was aware and I think it’s important to just know and like sometimes ‘oh I’m so tired but cause I didn’t get up’" - P06, full-time professional, treatment group

"[...] because like it reminds... I’m more conscious about it like about going for a walk or just try to get my 250 steps. Yeah, so I’m more aware of that." - P12, full-time professional, control group

5.3 Stages of Change Before and After the Study

Comparing participants stages of change before and after the study, we found that the stage of change of the majority of the participants did not change. However, four participants saw their the stage of their physical activity decreased. P08 changed from Decision/Action stage to Contemplation stage where P10 and P11 changed from Maintenance to Decision/Action and Contemplation to Preparation respectively. We also saw a change in P14, from Contemplation stage to Preparation stage (Table 5.1).

These changes were mainly due to the change in either their work or school schedule. For instance, P08 happened to start his summer semester where he attended multiple classes which he explained the reason why he wasn’t able to be as physically active as before the start of the study.

"[...] you know my schedule right now since I’m taking summer school, I’m a bit constraint to what I can do outside. So just because it’s summer, my ac-
Table 5.1: Participants’ stage of change before and after the study.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Pre-Study</th>
<th>Post-Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>P01</td>
<td>Maintenance</td>
<td>Maintenance</td>
</tr>
<tr>
<td>P02</td>
<td>Maintenance</td>
<td>Maintenance</td>
</tr>
<tr>
<td>P03</td>
<td>Contemplation</td>
<td>Contemplation</td>
</tr>
<tr>
<td>P04</td>
<td>Contemplation</td>
<td>Contemplation</td>
</tr>
<tr>
<td>P05</td>
<td>Maintenance</td>
<td>Maintenance</td>
</tr>
<tr>
<td>P06</td>
<td>Maintenance</td>
<td>Maintenance</td>
</tr>
<tr>
<td>P07</td>
<td>Contemplation</td>
<td>Contemplation</td>
</tr>
<tr>
<td>P08</td>
<td>Decision/Action</td>
<td>Contemplation</td>
</tr>
<tr>
<td>P09</td>
<td>Maintenance</td>
<td>Maintenance</td>
</tr>
<tr>
<td>P10</td>
<td>Maintenance</td>
<td>Decision/Action</td>
</tr>
<tr>
<td>P11</td>
<td>Contemplation</td>
<td>Preparation</td>
</tr>
<tr>
<td>P12</td>
<td>Maintenance</td>
<td>Maintenance</td>
</tr>
<tr>
<td>P13</td>
<td>Contemplation</td>
<td>Contemplation</td>
</tr>
<tr>
<td>P14</td>
<td>Contemplation</td>
<td>Preparation</td>
</tr>
</tbody>
</table>

*tivity level is a bit lower.* - P08, full-time undergraduate student, control group

Similarly, P11’s physical activity level decreased as she had multiple deadlines to meet during the study. She explained that, because of the increase in her workload, she did not have time to be as physically active as she wanted.

5.4 Self-Efficacy & Goal-Setting

Expanding on Knittle et al.’s work regarding goal-setting [32], we asked participants what they think about the 8-hour non-sedentary goal that we have set for them and if they would like to set their own goals. 13 of the 14 participants agreed that being able to set their own
goals would allow them to have a more realistic target and be more motivated to complete their activities. They expressed that personal goal-setting would allow them to have more freedom and controls over how much activity they can do on certain days. Some of them found that 8 minutes of walking in an hour to complete an hour of non-sedentary was very difficult for them to achieve.

"I think like if you have goals, you can customize what kind of goals you’re interested in having set for you. Right now I think it does it for you, so that’s one thing. So like yeah, instead of having it for like a week, maybe like you would have stuff to do for that week right? So like, if you were to set a goal for the month instead. […] Cause on certain days, I would be a lot more physically active right? Like say I am not free for the entire week except on like Saturday and Sunday, I would do a lot more sports on those two days so, yeah." - P04, full-time professional, treatment group

Four participants (3 from Treatment Group) also stated that failing to hit their daily non-sedentary hour goal was discouraging for them and that they started to lose interest in the extension after a number of days. Participants in the intervention group mentioned that they found the doctor’s image on the reminders annoying as they failed to complete their goals and the reminders kept popping up on their browsers. Toward the end of the study, they began to either ignore or close the reminders when they popped up. They agreed that it would have been better if the goal given to them was easier to achieve and the goal would increase over time when they consistently achieve the goal.

"I think figuring out your average and then pushing ten percent a week or something like that or whatever the number is; just having incremental, doing better than what you were previously doing is probably a lot better than some arbitrary number of steps or the number of hours or whatever it happens to be. Whereas
like the Carrot app is a good example of doing a baseline for two weeks and then kind of doing the progression that way" - P10, full-time professional, control group

"[At first] I thought 'oh, interesting guy!' but then he started like showing at my screen then I think because I got used to him, I didn't notice as much afterwards. So even if he popped up, I was like right away 'X' (clicking X to close the reminder)" - P06, full-time professional, treatment group

"Ok, at the beginning when I got it I was like 'OK, I felt kinda encouraged to be more healthy'. At the end of the third week, I felt discouraged because I cannot go out as much as I'd like to because I have the baby and I constantly got the reminder that I was behind my goal so it's like yeah I know I'm behind my goal, it's not like I can go right now and just leave as I wish. So yeah, I will say that at the very beginning I felt encouraged, at the end I felt discouraged because of the constant getting behind." - P03, full-time professional, treatment group

Another participant mentioned that if the goal could be set according to his schedule so he could have a lower non-sedentary goal on his inactive days and high non-sedentary goal on his active days. He believed that being able to achieve his goals this way could be more motivating for him to be physically active.

"[...] I think it's more on if it was built around my schedule or since my schedule isn't fixed right now it could be anything so if I could select from like today is gonna be a day I go shopping or I go for some interview or something so I will be out for a while and I could set a goal that matches how long I will probably be out versus when I am home that I am not going to do much activity so if I could set my goals myself then it would be better and more motivating
that way." - P07, treatment group

P01 believed that the extension should be able to have pre-set goal for the user however it should also allow users to set their own goals. He believed that an option for both would accommodate users who prefer to have pre-set goals as well as those who prefer to set their own goals.

"I think there should be option for both. Like you know, maybe some people don’t want to tinker around with that. You know, maybe people who don’t like messing around with their, you know, things on their phone but I’m pretty tinkery." - P01, full-time undergraduate student, control group

5.5 Intrusiveness Level

5.5.1 A Middle Ground for Popup Reminders

We also asked participants from the intervention group if they found the popup reminders to be intrusive and distracting. We got mixed responses from the participants. Two participants mentioned that they found the extension intrusive where three other participants said the reminders weren’t disruptive and they were fine with the reminders.

"[...] So, like I think the first day I installed it, or the second day, I didn’t really see any ads. But then after Wednesday or so, on the third day, I kept seeing it on everywhere actually haha. so I think near the end of it, it did get a little bit intrusive because it was appearing in places that I wouldn’t even normally think that it would appear in. Like for instance, there were a couple of company internal sites that it would just appear on the side of, in the top
corner." - P04, full-time professional, treatment group

On the other hand, one of the participants noted that she found the extension to be less intrusive than the Fitbit’s vibration feedback because she spends majority of her time in front of computer and it’s less intrusive because the visual feedback wasn’t distracting.

"Less intrusive. I can shut it(the extension) off. I mean I can shut this(Fitbit) off too but it’s like if I shut it off then I shut it off forever, whereas the computer one at least it’s only while I’m on the computer which is, I guess, the most important part of the day to be reminded to get up" - P06, full-time professional, treatment group

Three remaining participants in the treatment group were neutral regarding the intrusiveness of the extension. They believed that there were scenarios where they found the extension to be intrusive and there were scenarios where the reminders were acceptable and useful for them to be aware of their physical activity. For example, P07 stated that he felt that the intrusiveness of the extension depended on the size of the ad that it was replacing, the bigger the ad, the bigger the reminder, thus the more intrusive it was.

"When it appears on the top-right corner it’s fine but, like when I’m watching YouTube it sometimes appears and it’s a really big bar on the top-center part, and it pushes everything down. That one is a bit intrusive." - P07, treatment group
5.5.2 Visual, Audio or Haptic Feedback?

During the interview, participants were also asked to rank between three types of feedbacks, audio, visual and haptic feedback, in terms of their intrusiveness. Eight participants agreed that audio feedback would be the most intrusive where it can be very disruptive when they are working. There was a split in agreeing which feedback is the least intrusive with four participants in favour of visual feedback while four other participants were in favour of haptic feedback.

"So I’m thinking if you’re working in an office setting, you visually see something, you can click it away whereas if you have something like sound, it’s quite... It could be like if it’s a long beep then it’s quite annoying and then you have to click so it’s more annoying. And then the vibration, you can’t stop it right away, you have to wait till all the vibration done." - P12, full-time professional, control group

"I guess the most intrusive would be the noise cause people gonna hear that around you, then the vibration then the pop-up[visual], I don’t find that intrusive." - P09, full-time professional, control group

Another participant believed that the intrusiveness of the feedback depends on the task that the user is currently performing. For instance, if the user is relaxing away from the computer, the audio feedback would be the most distracting whereas the visual feedback would be distracting if the user is working on his/her computer.

"It really depends on the task I am doing at the time. So If I am working on something on my computer then something pops up on the screen, then the
visual one would be the most distracting. If I am relaxing or anything then a loud sound would be the most distracting. I don’t think the tactile feedback is strong enough to be that distracting. I think much of the time if it’s tactile I might even miss it if it’s using the Fitbit to do the notification that is." - P07, treatment group

5.5.3 Smaller Reminder, Less Distraction

Three participants in the treatment group thought that they popup reminders were too big and it would be better and less intrusive if the reminders were smaller. One of them stated that the size of the reminder was way bigger than the information inside, with less information displayed to the participants, he felt that the reminder can be shrunk down and can still display the same message. Another participant agreed that the reminder was bigger than the information inside needed and he felt that the reminder was quite intrusive because of its size.

"You can make it smaller like, it doesn’t matter the size like it is pretty big right now as it is with little information that was actually in the popup. But you can make it smaller and have the graph and maybe even a message as well." - P10, full-time professional, treatment group

"It was like massive. It was like "whoop". It was like a little bit of information in the middle of the box. Like ‘hey you haven’t done this’, or you had this many consecutive hours of non-sedentary activities." - P01, undergraduate student, treatment group
Having said that, a number of participants argued that they understood why the popup reminders needed to be bigger in size. They stated that bigger reminders can easily get their attention where smaller reminders might have gotten lost with other web contents.
Chapter 6

Discussion

The results from this study helped us understand how participants felt about the reminders that replace ads on websites as this is quite a novelty idea. Even though the quantitative data from this study showed no significant difference between the groups, the qualitative data yielded interesting information about participants’ responses to the extension. We believe that the qualitative commentary gained from the post-study interviews provide insights into possible design implications and how RA patients would perceive FitViz-Ad. In this section of the paper, we discuss the design implications that can be drawn from this study and how these implications relate to previous research studies.

6.1 Designing Non-Intrusive Reminders

Because participants were not asked to try using reminders with audio or haptic feedback, their responses regarding the intrusiveness of the three feedbacks were speculative and might not be as conclusive as if they were using all three. However, based on their responses, we can also speculate that FitViz-Ad’s use of visual feedback alone can be appropriate and not too intrusive that would interrupt the user’s current task.
However, we understand that the content of the reminder should be improved in terms of the image and the message. The use of a different image or visual representation could be more useful and effective than a generic doctor’s image. It should also be noted that a number of participants stated that the repetitive display of the same image became annoying for them and they started to lose interest in the reminder and started to ignore the reminders. Participants also did not discuss much about the message on the reminder as they tend to close or ignore the reminders when they saw the doctor’s image and did not get to read the message left for them. Thus, future designs for reminders should consider using a variety of visual elements that can help provide useful information as well as a variety of messages to encourage or congratulate the user when a goal is achieved. Even though this is a short study, we believe that if appropriate messages were used like Matsuddi and Connely’s work[12] positive results can be achieved. The balance between the visuals and the message displayed should also be considered so that the users would spend time reading the encouraging message left for them.

Based on the responses we gathered from our participants, we think that it is worth exploring the use of different type of feedbacks. Even though a majority of the participants felt that audio is the most intrusive type of feedback, some others felt differently based on their workplace environment or the task that they were doing. Developers should consider providing options for participants to pick the type of reminders based on their needs as well as providing an option to mute the reminder for a period of time. This point was brought up by one of the participants that experienced the reminders popping up during one of his presentations in which he suggested that an option to mute the reminder would be really helpful.

6.2 Alternative Notification Technologies

Although our study focused heavily on the notion of replacing online ads with reminders about one’s physical activity, findings from the study can be used to explore other types
of notification technologies. Using wearing devices like Fitbit trackers to alert the users through haptic feedback can provide a different experience. While participants in the study reported that they got used to seeing the reminders when they were surfing the web and began to ignore the reminders, the experience that they might get from the vibration from wearable devices might not be something that they can ignore. This can either force them to follow the reminders and walk around whenever they are notified or they might begin to feel annoyed or disturbed due to the vibration. The annoyance and disturbance that wearable devices may cause may force them to take off and stop using the device. Similarly, if smartphones were used to notify the users, they might end up muting the phone or turning off the notifications should they constantly feel that the audio feedback from the phone is disruptive.

Because we want to focus on those who spend most of their time sitting in front of their computers, it is worth exploring making use of other objects commonly found on a working desk. For instance, some of today’s peripheral devices like mice and keyboards have LEDs that the users can change to different colours (Figure 6.1). Future designs can consider making use of these keyboards and mice to notify the users. A mouse can emit green colour when the user is on track to achieve their goal and red when the user is behind so he/she needs to get up and walk. We believe this can be an alternative approach to explore in terms of non-intrusive reminder.

6.3 Maintaining Interest Through Realistic Goal-Setting and Rewards

With a majority of the participants reported to have lost interest midway through the study because they repeatedly failed to achieve their daily non-sedentary goal, we began to understand the importance of early engagement to keep the users interested in the exercise goals. For someone to change his/her lifestyle, there needs to be sufficient time given for the change to happen while in the meantime maintaining their interest in the tool. In
order to sustain the lifestyle change that the user aims toward, different measures can be implemented to ensure that the user remains interested in the tool so that it can be an effective tool in the long run. One of the measures that we have learned from the study is goal-setting. With appropriate goal-setting, the tool can ease the users into the routine of being physically active thus wouldn’t leave them to feel frustrated and lose interest when they fail to achieve their goals. We come to understand that getting users to be interested in the tool when they first start using it is very important to sustain their usage. In other words, users need to be ‘hooked’ to the extension early on to keep them interested in order for the tool to be effective.
Like Knittle et al. found in their study [32], participants wanted to have an option to set their own goal which they believed would help them establish a more realistic goal to aim for. However, given that the extension target users would be RA patients, we believe that there should be a balance in how much control the user has in goal-setting as pointed out by Plasqui [60]. Future implementation of similar physical activity reminders should consider providing the control of goal-setting to both the user and the professional physician or doctor. For instance, the physician or doctor can prescribe a daily goal of 8 non-sedentary hours however the user can set an easier goal to start with like 2 non-sedentary hours per day. Once the user consistently achieves that goal, the tool can gradually increase the goal toward the prescribed goal of 8 hours. With this approach, we believe it can help the user ease into the habit of achieving the goal by starting with something that is achievable for the user, thus preventing the user from losing interest by failing to achieve his/her daily goal.

Figure 6.2: Fitbit’s digital badges rewarded the users for completing 20,000, 25,000 and 30,000 steps a day.
Another measure that can be used to sustain user’s usage and interest in the tool is a rewarding system. Users should be rewarded for achieving their daily goals. We tried to implement this aspect by providing a congratulatory and encouraging message when they achieve their goals, however, the study proved that a simple congratulatory message alone might not be enough to sustain their interest. Multiple health tools on the market today have incorporated various reward system into their products. Fitbit, for instance, rewards its users with digital badges that show up on their Fitbit profile [16]. Rewards are granted to users when certain milestones are achieved. For example, achieving 30,000 steps a day would earn the user a 'Trail Shoe' badge (Figure 6.2). However, digital trophies and badges alone were shown to have failed to motivate participants to be physically active [50]. Thus, multiple third-party companies have reward programs where users can link up their Fitbit accounts and they can earn loyalty points, shopping discount or cash based on their physical activity achievements [42]. One of those reward programs is “Carrot” rewards app which rewards Canadian residence with loyalty points for completing educational health quizzes and/or completing their step count goals [48]. Users can use their loyalty points toward movies or groceries giving them incentives to complete their daily step goals. Having presented the results from this study and overviewing these approaches to reward users, we believe that having a reward system in place for FitViz-Ad might have been a good measure to keep the participants interested in the tool and motivated to be physically active. It is worth exploring the idea of implementing in-tool reward system like digital badges and trophies as well as practical incentives like loyalty points. Obviously, real-life incentives bring up its own logistic challenges though we believe that this reward system could potentially be very effective in engaging users in the long run.

6.4 Physical Activity Awareness

At the beginning of the study, we did not pay a lot of attention to the effect that FitViz-Ad would have to participants awareness as we were more focused toward the non-intrusive aspect of the reminder. With a number of participants reported to be more aware of their
physical activity level while using the extension, personal awareness regarding one's physical activity should be further explored especially in our design. From our findings, it appeared that participants were more aware of their physical activity level just by simply wearing the Fitbit tracker every day although we believe that this novelty effect would wear off after a period of time.

A number of participants also reported having taken advantage of the non-sedentary hour goal by opting to take a walk in between two hours. For example, one participant stated that because he needed to walk at least 8 minutes in an hour he took advantage of the system by choosing to walk between 10 and 11 AM. The participant mentioned that by taking a walk from 10:50 AM to 11:10 AM, he could complete 2 non-sedentary hours with a single walk as compared to taking two separate walks. Some participants also reported having taken advantage of their commute to work or school to try to complete their non-sedentary hour goal. They were glad that they could complete 1 or 2 non-sedentary hours by taking public transportation which required them to walk to the bus stops or train stations. Some suggested that they intentionally took a detour or went for a further stop to try to complete their goals. With these findings, future development could explore taking advantage of these voluntary behaviours. For example, the tool can strategically remind the users about their physical activity level rather than reminding them at the same time every day. If one gets off work at 5 PM and is 2 hours away from completing one's daily non-sedentary goal, the tool can remind the user at 4:30 PM that he/she only has 2 more hours to complete thus giving the user a chance to plan the commute home by taking a longer route, for instance. This kind of strategic reminder can help the users to become more aware of their physical activity and plan when they can be physically active to fit their daily schedule.
6.5 Implementation Challenges & Critiques

6.5.1 Malicious Web Content Lookalike

Throughout the development of FitViz-Ad, we encountered a number of technical challenges and design questions that were important in how we approached the development of this extension. Due to the novelty idea of replacing online advertisements, we were not certain in how the users would react to seeing the content of a web page changes while they are visiting. Our initial concern was that the users might be worried about potential malware or virus infecting their machine. This concern was later confirmed in the study where a number of participants stated that they thought the popup reminder was a virus infecting their machine because they simply forgot about the study. Because the study did not have any specific instructions for the participants, most participants did not pay close attention to the extension until they were first reminded to move around. We agreed with the findings and propose that future design iterations of FitViz-Ad would see a change in overall look and feel of the popup reminders to avoid any potential confusion with malicious web contents.

6.5.2 Replacing Ads on an Ad-less Page

Another implementation challenge that came up during the development process was addressing the question in which there are no online ads on an existing web page. The solution that we came up with this study was to place the popup reminder on the top right corner of a web page. The reminder was intentionally programmed to place itself on the top right corner without making any changes to the web content itself. This means that if the user is viewing content in the middle of the page, the reminder does not force the page to scroll up to the top when the reminder is placed on the page. Participants would possibly not even notice any changes to the page if they do not manually scroll to the top of the page. This implementation also allows the extension to function even with Adblock installed on the Chrome browser. This approach raised a concern that could undermine the effectiveness
of the extension because the extension may not be visible to the participants when they should be reminded. To overcome this concern, FitViz-Ad gets executed on all opened tabs on the browser regardless of whether or not the page is being viewed by the participant. We were quite satisfied with our approach to this challenge and the feedback that we got from the participants also agreed with our justifications.

It is also worth noting that we did not log how often participants saw the reminder on the top right corner or when the ads on the page got replaced by the reminders. However, based on the post-study interviews, all participants in the treatment group mentioned that they saw the reminder for a number of times during the intervention phase. We believe that participants may have missed a few reminders within a workday based on what they were doing when the reminder showed up, however they still managed to see one or two reminders from other opened tabs.

Participants generally appreciated how stealthily the extension functioned in the background without disrupting their work. They were somewhat appreciative that the extension could run on all the opened tabs which allowed them to be more likely to see the reminder where otherwise they might have missed. However, because there is no way to close the reminders across all the tabs at once, they found it troublesome to have to close each reminder manually. Thus, a suggested feature in which there should be a button to close all reminders was raised in the finding. We acknowledge that this feature would be very helpful for those who tend to have a lot of tabs opened at once. Based on the findings reported in the Results section regarding the size of the reminder, future iterations should see a shrink in size of the reminder as well adding more controls to close or hide the reminder to improve the extension’s usability.
6.5.3 Shouldn’t the Participants be Reminded Even if it is Impossible to Achieve Because Some is Better Than None?

Unlike people with no physical difficulties, people with RA need to pay extra attention to how much physical activity they can do. Due to the nature of the disease, there is an increased risk of injury for people with RA [60]. Thus, the debate about not reminding participants if it is impossible to achieve the goal given the remaining time turned out to be a challenging question to answer. Given that physical activity is proven to be an effective approach in maintaining RA disease and overdoing it risk injuries and worsen the disease [11, 19, 47, 60, 71], we believed that the measure that was implemented in FitViz-Ad to not remind participants when it is not possible to achieve the goal can potentially be more beneficial for people with RA in a long-term usage.

This question was not addressed in the results of this study because the majority of the participants only installed FitViz-Ad on their work machine or only used FitViz-Ad during the day. In other words, participants did not use FitViz-Ad in the evening in which they might have possibly missed the last two reminders of the day (7 PM and 10 PM). With these two reminders missing, participants were not made aware of their physical activity at the end of the day unless they had checked their non-sedentary hour progress on their work machine before they left work. Participants also reported to not use the extension over the weekend because a number of them did not normally spend time in front of the computers outside the weekdays.

This begs the question of how people with RA can be reminded when they are not sitting in front of the computer. People might sit on the couch or lie down elsewhere away from the computer when they do not work, especially on the weekends. One of the design implementations we hope to accomplish in the future is to be able to use Fitbit tracker that the user wears as reminders. For example, if the user is away from his/her computer and is behind the daily non-sedentary goal, the Fitbit tracker would vibrate to remind the user. As of writing this, there is currently no possible way of sending notifications directly to a
Fitbit tracker. Another solution is to develop a mobile app in which push notification can be sent directly to the user’s personal device. Both solutions involve a separate device that requires the users to either wear or carry with them. Because the intended users are those who spend the majority of the day working in an office setting environment without physical activity, we are convinced that having FitViz-Ad extension available to only browser usage is appropriate to evaluate the effectiveness and usability of this form of non-intrusive reminder.

6.6 Addressing the Research Question: Can Non-Intrusive Reminders Effectively Encourage Physical Activity?

Even though findings from the study showed that subtle reminder was not effective in encouraging physical activity, they showed that participants were more aware of their physical activity especially when they have been sitting at work for a long period of time. Data collected during the study showed that there was no significant difference between those who were exposed to non-intrusive reminders and those who were not, however, participants in the treatment group who used the full version of FitViz-Ad extension with pop-up reminders were more expressive during the post-study interviews about their physical activity during the week because they were more aware of their activities.

On top of that, some participants expressed that they are interested in this concept of non-intrusive reminder. They suggested that would want to continue using the extension if they own a Fitbit tracker or if more features were implemented to accommodate their lifestyle. We think that non-intrusive reminders alone may not effectively encourage physical activity, other measures like goal-setting and reward system should be incorporated to improve the effectiveness of the tool. Non-intrusive reminders would allow the users to be more aware of their physical activity and other mentioned measures are potentially beneficial in keeping the users interested in the tool. We believe that more comprehensive studies are needed to understand if there are effective times to remind people to be physically active.
and the motivations that the tool can give so help to maintain and improve physical activity level.

6.7 Implications for People with Rheumatoid Arthritis

Even though the study did not recruit people with RA, we believe that the findings from the study give us a glimpse of what we can expect from participants with RA when a clinical trial is conducted. Participants in this study were selected because they were in the groups that tend to spend majority of their time sitting in front of computers without doing much physical activity. Based on the findings, we can begin to speculate how people with RA would use the extension and this would also give us an opportunity to make adjustments to the features and functionalities of FitViz-Ad to be more suitable for different usage.

In future clinical trials with RA patients, we will have to pay careful attention to the daily goal that would be prescribed to the participants. Future study needs to ensure that participants with RA would receive counselling from physiotherapists or doctors prior to the start of the study to define appropriate daily goals for them. The likelihood of the prescribed goal to be achieved should also be discussed with the participants prior to the study in which we would be able to adjust the prescribe goal to be something that they can achieve to start off with. This measure is to ensure that participants would not lose interest in the extension during the study which we found out in this early study of FitViz-Ad.

We think that RA patients would find the extension to be useful in providing them with the physical activity awareness and to some degree, remind them to be physically active when they should be. They might not see any changes in their physical activity level in the early usage but we are hopeful that the personal awareness that the extension provides could be insightful for RA patients to understand why they need to be physically active and prepare them to be ready for a lifestyle change. Having said that, it is possible that they would begin to lose interest in the extension after a certain period of time if they find their goals too hard to achieve. Thus, appropriate design considerations regarding the use of
reward system and other measures should be explored before the extension could be ready for RA patients to use.

On top of that, we hope to present RA patients with a tool that was specifically designed and built for them using technologies that were not necessarily intended to be used by them. As we mentioned earlier, one of the main inspirations behind FitViz-Ad is the lack of tool for RA patients in the market. We hope that this project can inspire other projects to pivot the purpose of commercial products for specific user groups that are left out.

6.8 Limitation

We also have to acknowledge that our study was only a 2-week long study and it might not be sufficient to change someone’s lifestyle. Multiple studies [36, 12, 28, 32, 74] mentioned in this paper spanned across a long period of time (more than 3 months) which yielded somewhat positive results regarding the change in one’s lifestyle. With more resources, we could expand on this study to be a longer study as well as recruiting more participants in different stages of their readiness for change [62]. However, this short study has provided with insights into improving FitViz-Ad and given us an opportunity to evaluate the novel concept of non-intrusive reminder.

We should also note that participants were not asked to try out audio and haptic feedback and they were asked to speculate the intrusiveness level between visual, audio and haptic. We assumed that the participants have prior experience with the traditional audio feedback and haptic feedback from the Fitbit tracker. Due to these speculations, their responses might not be as conclusive as if they were given a chance to try out all the three feedback types.
6.9 Future Design Iterations

After having evaluated FitViz-Ad and analysed the results, we felt the need to come up with a few design iterations based on some of the points addressed earlier in the discussion. We have drafted a few design iterations based on the findings which aim to improve the user experience of FitViz-Ad. One of the design changes that we focused on is the reminder itself. With a number of participants addressed the concern of its size being too big and how they were initially thought of the reminder as some sort of malicious web content, we came up with a few changes to improve the look and feel of the reminder and the information presented. Another design change that we address below is how information is clustered with detailed information is now gathered into one location allowing for minimization of the popup reminder. It is also worth noting that these proposed design changes have not been implemented and they are not to address all the discussion points made earlier in this section. Some of the key discussions like allowing the users to set their own goals and gradually increase those goals to meet the clinician’s prescribed goals still need further evaluation with RA patients.

6.9.1 Redesigning the Visual Representation

In this design iteration, the reminder’s size has been decreased and the user is presented with an avatar version of a doctor\(^1\) instead of an actual picture of a doctor (Figure 6.3). The message displayed tells the users how many hours of non-sedentary are still needed to stay on track to completing the daily goal (e.g. "You are 3 hours behind your target."). We have also removed the non-sedentary hour progress and goal from the reminder because it’s a redundant information in which the users can click on the extension to find out more about their progress. This change was based on the suggestions from a few participants who expressed that they did not bother to read the actual number of non-sedentary hour because they already knew they were behind their goals. We have transformed that piece of

\(1\text{Avatar from Vecteezy.com}\)
Figure 6.3: A redesigned popup reminder telling the user to get up and walk more to stay on track.

The reminder converts textual information into filled and unfilled white circles to represent the same information. Filled circles and non-filled circles represent the amount of non-sedentary hours completed and not completed respectively with each circle representing a one-hour unit. Moreover, the redesigned reminder also tells the users that it is generated by FitViz-Ad extension by specifying "reminder by FitViz-Ad" right on the reminder. By this measure, we hope to eliminate the concern regarding the confusion for malicious web content. If the daily non-sedentary goal is completed, the popup reminder shows up green instead of orange giving out an idea of a positive accomplishment. The reminder is accompanied by a congratulatory message and visual² and all the white circles are filled (Figure 6.4).

These screenshots showing a redesign FitViz-Ad reminder that works on a web page with no online advertisement. For consistency, a number of changes have also been made to the popup reminders that replace ads on websites. For instance, one of the Facebook's

²Visual from Vecteezy.com
Figure 6.4: A redesigned popup reminder congratulating the user when the daily non-sedentary goal is achieved.

ad is replaced with a redesigned popup reminder but still retains the original size of the ad (Figure 6.5).

6.9.2 Separating Information & Reminders

The popup box which appears when the extension icon is clicked on the browser has also been redesigned to address some of the issues raised in the study (Figure 6.6). With the changes, the users will be able to briefly mute the reminders when they are in an important meeting or they can close all reminders with just a single click rather than closing the reminders on each tab manually. The visual representation of their non-sedentary hour progress with respect to their goal has also been changed. In this design iteration, we would like to provide the users with all the details in this popup dialogue which allows the popup
Figure 6.5: A redesigned popup reminder appears on Facebook newsfeed.

reminder to only provide the user with the basic reminder that they need, minimizing the distraction that might have caused.
Figure 6.6: Redesigned popup reminder congratulating the user when the daily non-sedentary goal is achieved.
Chapter 7

Conclusion & Future Work

In this thesis work, we introduced FitViz-Ad, a non-intrusive reminder that reminds RA patients to be physically active. We presented the design principle behind FitViz-Ad and its implementation. We conducted a usability evaluation with 14 participants and reported the findings. We discussed some of the key findings and suggested possible design implications. Though it is not common, we mocked up some design changes based on the findings and presented them as proposed changes for future design iterations.

Even though the findings showed that participants that used FitViz-Ad with non-intrusive reminders were not more physically active, we gained a number of insights into how reminders should be designed to suit RA patients. For future work, we aim to implement the changes based on the findings that we proposed in the discussion. We hope to use this opportunity to refine and adjust FitViz-Ad to better suit RA patients. Another aspect that we have not fully explored is Gamification\[36, 64, 65\] and point system among a social group in which users can be rewarded with points by completing their goals and compete with other users.

Another possible future research that came up during this study is regarding the appropriate time to remind people. During the study, we realized that there was a lack of research work about the “golden” time of when to remind people to do something. We
designed FitViz-Ad to remind users at 5 specific times which we believed would be best for those who spend a majority of their days in front of computers. Future possible research question would be to ask if there is a “golden” time in which it is more effective to remind the users than any other time of the day? As stated earlier, we also hope that our study can be a stepping stone for more research work relating to reminders and health and fitness encouragement. We encourage other researchers to expand on this study and explore other possibilities into transforming existing commercial products to be useful to those whom the products might not have been intended for.
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[70] Stack Overflow. Advertise | Stack Overflow Business.


Appendix A

Ethics Application Study # 2016s0625  PRE-STUDY QUESTIONNAIRE December 17, 2016, Version 2

FitViz-Ad Pre-Study Questionnaire

What's your name?

How old are you?

Do you currently own and use a Fitbit device?
  ○ Yes
  ○ No

How long have you been using Fitbit?
  ○ Less than 2 weeks
  ○ Between 2-4 weeks
  ○ Between 4-6 weeks
  ○ More than 6 weeks

What's your purpose in using Fitbit?

How often do you check your progress on Fitbit website?
  ○ Never
  ○ Everyday
  ○ Once a week
  ○ Once a month
Appendix A

How many hours do you spend in front of computers surfing the web each day?
○ 0
○ 1
○ 2
○ 3
○ 4
○ 5
○ 6
○ 7
○ 8
○ 9
○ >10

Physical Activity Stages of Change
For each of the following questions, please choose either Yes or No. Be sure to follow the instructions carefully.

Physical activity or exercise includes activities such as walking briskly, jogging, bicycling, swimming, or any other activity in which the exertion is at least as intense as these activities.

I am currently physically active.
○ Yes
○ No

I intend to become more physically active in the next six months.
○ Yes
○ No

For activity to be regular, it must add up to a total of 30 minutes or more per day and be done at least 5 days per week. For example, you could take one 30-minute walk or take three 10-minute walks.

I currently engage in regular physical activity.
○ Yes
Appendix A

Ethics Application Study # 2016s0625  PRE-STUDY QUESTIONNAIRE December 17, 2016, Version 2

☐ No

I have been regularly physically active for the past 6 months.

☐ Yes

☐ No


Contact

If you're selected to participate in the study, you will be contacted through the information you provide below.

Email Address:


Phone Number:


Appendix B

FitViz-Ad: A Nonintrusive Personal Reminder Tool to Support and Motivate Chrome Users with Physical Activity

POST-STUDY INTERVIEW QUESTIONS

Participant No: __________________________
Participant Name: _________________________
Date: _________________________________

1. Now that you’ve used FitViz-Ad for a week, can you tell me about your overall experience with the tool?
______________________________________________________________________________
______________________________________________________________________________

2. Can you recall any particular positive experience with the tool? If yes, explain.
______________________________________________________________________________
______________________________________________________________________________

3. Can you recall any particular negative experience with the tool? If yes, explain.
______________________________________________________________________________
______________________________________________________________________________

4. Have you used any other reminders before? If yes, any of those reminders related to mobility?
______________________________________________________________________________
______________________________________________________________________________

5. How would you compare FitViz-Ad to other reminders?
______________________________________________________________________________
______________________________________________________________________________
6. How would you describe your first impression when you see a reminder that replaces the ad on the webpage that you’re visiting?
________________________________________________________
______________________________________________________________________________

7. Do you think the reminder you receive motivates you to move around when you’ve been sitting in front of computer for a long period of time? Why or why not?
________________________________________________________
______________________________________________________________________________

8. What other information would you want to see on the reminder?
________________________________________________________
______________________________________________________________________________

9. Do you have any features in mind that you think FitViz-Ad should have to further improve your user experience?
________________________________________________________
______________________________________________________________________________

10. Personally, what do you think would be the motivational factor for you to move around after a long period immobility?
________________________________________________________
______________________________________________________________________________