The Development and Implementation of a Gamified Stair Climbing Intervention at an Individual Level

By

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A thesis submitted in partial fulfillment of the requirements for the degree of

Master of Arts

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Abstract

The addition of gamification in the health promotion field is an up and coming method that is being utilized to raise engagement and keep more participants involved to maximize the effectiveness of interventions. Gamification is most often used in conjunction with technology such as web-based interventions. Because this method is new there is limited research to show if gamification is an effective tool. The results of this study seek to help fill this void.

Methods:

A total of 109 participants were recruited from two work places in Edmonton, Alberta (three work sites). One work place was allocated to the intervention group and the other work place (two work sites) was allocated to the control group. A Solomon Four Group design was used for this study; a two-week baseline was used as the pretest. Both groups used the Fitbit One physical activity monitoring device to record the number of stairs they climbed. The control group recorded their stairs on a generic website that provided only numeric feedback; the intervention group recorded their data on a website that was built with gamified elements included.

Results:

A significant increase was found in the number of stairs climbed by the intervention group regardless of the presence of baseline, $F(1, 29) = 4.20$, $p = .05$. No significant correlation was found between engagement with the website and number of stairs climbed, $r = .251$, $p = .067$. When self-efficacy was broken down into the three categories no significant correlation between task self-efficacy

and stairs climbed, $r = .097$, $p = .357$. However, significant positive correlations was found for both coping and scheduling self- efficacy, $r = .251$, $p = .039$ and $r = .237$, $p = .023$ respectively.

Conclusion:

The results of this study are encouraging with respect to the use of gamification as a tool to maximize the effectiveness of web-based physical activity interventions. Due to the study design used in this study we were able to isolate the effects of gamification and can say that there is a place for gamification within web-based interventions. The positive effects of gamification led to the intervention group to increase the number of stairs they climbed significantly more than the control group. The results of this study also lend support to the use of stair climbing as a modifiable target beahviour in a workplace setting.

Preface

Except where acknowledgement has been made, the work in this thesis is that of the Shayna M. Fairbairn. This work has not been submitted previously, in whole or in part, to qualify for any other academic distinction. The content of the thesis is the result of work carried out since the official commencement date of the Master of Arts program at the University of Alberta in the Faculty of Physical Education and Recreations.

The research project of which this thesis is a part, received research ethics approval from the University of Alberta Research Ethics Board as the “Stair Climbing Pilot Test” amendment to Project Name “UWALK: A province wide multi-strategy physical activity promotion project” PRO.00041719, July 22, 2013.

Chapter 4 of this thesis is a paper that will be submitted for publication, with Shayna M. Fairbairn as primary author and Cally Jennings, Eleni Stroulia, & Kerry Mummery as co-authors.

Acknowledgments

I would like to acknowledge the people who helped make this study possible. My supervisors Dr. Kerry Mummery and Dr. Cally Jennings. The UWALK team Kenton Delisle, Jill Carlson, and Nicole McLeod. And finally my family for all of your support.

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Chapter 1: Introduction

One of the major crises of the modern day from a health and well-being standpoint comes in the form of chronic diseases or non-communicable diseases. This category of ailments includes but is not limited to, heart disease, type II diabetes, stroke, and cardiorespiratory diseases. One of the main correlates of all of these diseases is a lack of daily physical activity. As our world has become more mechanised, the incidence of bouts of daily physical activity has decreased and our society has become increasingly sedentary (Haskell et al., 2007).

Physical activity interventions have historically had issues with participants remaining engaged throughout the intervention. In an attempt to raise engagement this study used an intervention based on gamification. Gamification refers to the inclusion of elements that make games engaging and keeps players playing them, and applying them to situations where engagement is often lacking. This study was be set in a work place and had a web-based delivery. The study was six weeks in duration: two weeks baseline followed by four weeks of website monitoring. A web based control group was utilized with generic website that is stripped of all of the gamified features. The only functions of the generic website are logging flights of stairs and viewing previous logged flights.

The physical activity behaviour that the study targeted was stair climbing. It is an appealing target behaviour because stairs are readily available in modern society, they can be climbed both inside and outside so weather becomes a non-factor, and climbing stairs does not require a significant time commitment or special equipment. To track stair climbing as a modifiable behaviour the Fitbit One (Fitbit Inc.) physical activity monitoring device was used. The Fitbit One is a tri-axial accelerometer that contains an altimeter that records flights of stairs climbed.

The results of this study will help to fill gaps that exist in the literature relating to the role of gamification in web-based physical activity interventions.

1.1 **Purpose**

The purpose of this study is to implement and examine the efficacy of a gamified web-based physical activity intervention with the aim of increasing mindful stair usage in a workplace setting. Specifically, we sought to increase the number of flights climbed weekly with the use of goals and self-monitoring integrated into an interactive gamified website as the main intervention element. Stair climbing was measured using an objective physical activity monitor (the Fitbit One), which includes an altimeter that allows for the automatic recording of flights of stairs climbed. This intervention is part of a larger province-wide physical activity promotion program entitled UWALK. This study serves as the first stage of evaluation to determine if this type of challenge is effective in influencing behaviour. The current study will also provide some understanding into the effects of gamifying an interactive health promotion website.

1.2 **Significance of Study**

It is widely accepted that our society is not sufficiently active and this in turn increases the incidence of chronic diseases, which are currently the leading cause of death in the developed world (WHO, 2013). This study targets stair climbing, an area of physical activity that has been widely overlooked in the world of individual interventions. Stair climbing has been shown to lower the risk of cardiovascular diseases in individuals who climb more than fifty-five flights of stairs each week (Paffenbarger et al., 1993). In addition stair climbing is an appealing behaviour to target because stairs are readily available and their use can be an opportunity for regular incidental physical activity that can be integrated into a person's life without the need to drastically change their daily routine. This study was conducted in a workplace setting due to the sedentary nature of the work performed there. Interventions like the one in this study could be used to help inoculate workers against the harm caused by having a sedentary job. The use of gamified interventions is a new area of research in health promotion, and this study offers one of the first individual-level stair-climbing interventions using a gamified approach. This study is novel in that it incorporates multiple elements from gamification (storylines, competition, rewards, and interactive progress maps). This study is also one of the first that focuses on changing stair-climbing behaviour at the individual, rather than group level. This approach offers the promise of increasing the understanding of interventions to increase workplace physical activity.

1.3 **Research Questions**

The primary research question in this study is "Does gamification enhance web-based behavioural change interventions?"

In addition the construct of engagement will be measured through analytic functions built into the gamified website. These functions are only available in the gamified site so engagement will be measured within the intervention group. The secondary research question for this study is "Does a relationship exist between engagement with the website and change in the target behaviour?"

The third question that will be examined in this study is "Is there a relationship between self-efficacy for pre-set goals and behaviour?"

1.4 **Hypotheses**

1.4.1 **Primary** Hypothesis. The main hypothesis for this study is that the use of gamified elements in a website will have the participants in the gamified group increased the number of stairs they climbed significantly more than the control group participants. The weekly total flights will be compared between the second week of baseline and the last week of the intervention for each group.

1.4.2 **Secondary Hypothesis.** The hypothesis for the secondary outcome is that there will be a positive correlation between engagement with the website (number of times activity was logged) and the number of flights climbed by participants.

1.4.3 **Tertiary.** The hypothesis linked to self-efficacy will be tested using a correlation between scores on the modified Multidimensional Self-Efficacy for Exercise Scale (MSES) and number flights climbed. We expect to find a positive relationship between self-efficacy for pre-set goals and flights of stairs climbed.

1.5 **Delimitations**

The scope of this study is limited to the stair climbing behaviours of individuals working in two selected office environments in Edmonton, Alberta, Canada. The physical layout of the buildings is limited to multi-story buildings with accessible stairwells. Two provincial government ministry departments are being used for this study. A convenience sample used has been selected for this intervention, mainly due to financial restrictions and the availability of physical activity monitoring devices (Fitbits).

1.6 **Limitations**

One potential limitation of this study is that outcomes are dependent upon the participant's engagement with the websites. Engagement will be tracked throughout the duration of the study. Website analytics will provide information on participant's engagement with the website: records will be kept with regard to how often participants are logging their flights of stairs (for example are they logging flights each day or a week at a time).

While the use of a quasi-experimental design will mitigate a social interaction threat that may occur if participants were in the same work place the risk of inequality between the groups becomes a factor. To correct for this, baseline data was be collected from both sites. If the sites are not found to be equal then difference scores will be compared from baseline in place of raw data.

Another potential limitation is the recruitment process. Instructions have been given to the work places as to how this intervention should be advertised and promoted however because we are not on site it is possible that one work place may promote the intervention more intensely. Participants are also volunteering and being selected on a first come basis for this study so there is a self-selection bias that will be present. The sample size calculations for this study are based on a moderate effect size being detectable; this is potentially limiting the results that can be found.

1.7 **Definitions**

Contingent Rewards – An achievement that an individual receives only after a predetermined behaviour is performed (Ryan, Mims, & Koestner, 1983).

Gamification/gamified – Refers to using elements of game design including rewards, rules, missions/objectives in non-game situations in order to increase engagement (Garris, Ahlers, & Driskell, 2002).

Self-Efficacy – An individual's belief that he is able to complete a specific task or goal. There are three subtypes of self-efficacy (Bandura, 1977).

Task Self-Efficacy – An individual's confidence that she can perform the actual elements of a specific task or goal (Maddux, 1995).

Scheduling Self-Efficacy - An individual's belief that he will be able to integrate a behaviour into his life (Maddux, 1995).

Coping Self-Efficacy – An individual's belief that she will be able to perform a task when faced with obstacles (Maddux, 1995).

1.7.1 **Operational definitions**

Engagement – How many separate occasions participants log their flights of stairs on the website. This will be measured using analytic software that is built into the website.

Flights – For the purpose of this study the definition of a flight used by the Fitbit One will be used across this study, which is a change of ten feet in elevation is equal to one flight of stairs.

To address gender biased language throughout this thesis I will alternate pronoun usage (he/him and she/her) for each section where applicable.

Chapter 2: Literature Review

2.1 The Role of Physical Activity in Health and Well-being

There is evidence to support the role physical activity plays in health and wellbeing (Lee & Paffenbarger, 2000; Macera, Hootman, & Sniezek, 2000; Kesaniemi et al., 2001; Oguma, Sesso, & Paffenbarger, 2002; WHO, 2013). The inclusion of physical activity in a person's daily life can have an inoculating effect against a wide range of diseases and disorders. One of the strongest associations is between increased physical activity and decreased heart attacks and all-cause mortality (Lee & Paffenbarger, 2000; Oguma et al., 2002). Many bodily mechanisms are affected by an increase in physical activity. The main cause of overweight and obesity in the world today is an energy imbalance (people are taking in more calories than they are expending). By increasing physical activity people expend more calories and can achieve a more balanced energy level (WHO, 2013). An increase in physical activity can also in, among many other benefits: a reduction of abdominal fat deposits helps to control weight, lipid lipoprotein profiles are enhanced (this increases the levels of HDL cholesterol and decreases the levels of LDL cholesterol in the body), and there is an increase in the body's ability to regulate glucose levels - important in the prevention of type II diabetes (Warburton, Gledhill, & Quinney, 2001). Various types of physical activity are useful in achieving health benefits, including walking, organized exercise and stair climbing.

2.1.2 **Stair climbing.** Stair climbing is a unique form of physical activity because the structures are readily and do not require any special equipment. Stair climbing refers to the act of walking up stairs. There is a known relationship between people who climb at least 55 flights of stair per week (a flight is equal to 10 steps) and a lower relative risk of heart attack (Paffenbarger et al., 1993; & Boreham, Wallace, & Nevill, 2000). The positive effects from stairs climbing are only found for stair assent not descent (Boreham et al., 2000). An intervention that targeted the stair-climbing behavior of sedentary women found that by gradually increasing the number of flights of stairs the women climbed each day there was a significant health benefit in the areas of cardiorespiratory fitness and cholesterol regulation (Boreham et al., 2000). The significance of this study is the finding that even a small increase in stair-climbing activity can have a marked impact on the health of sedentary individuals. Targeting stair climbing, as a modifiable behavior is appealing because it is an area of physical activity behavior that has the potential to have a large and lasting impact on health.

Stair climbing is a vigorous activity that uses over six times the energy than is expended at rest (Ainsworth et al., 2000). It is an entirely free activity that does not require an individual to drastically alter his or her lifestyle to accommodate this new behavior.

2.2 **Correlates of Physical Activity**

Much of the research in the area of health promotion is concerned with why people chose to either engage or refrain from physical activity. Because much of the work done in this area is correlational and not experimental it is more appropriate that the findings are referred to as correlates of physical activity rather than determinants. Three overarching categories were found in the literature and will be addressed about in this section; those categories are social, environmental and psychological factors.

2.2.1 **Social**. Social correlates refer to the influence an individual's social group can have on the decisions that they make. The impact that an individual's social group can have on the amount of physical activity that an individual engages in is well documented in the literature (De Bourdeaudhuij & Sallis, 2002; Plotnikoff, Mayhew, Birkett, Loucaides, & Foror, 2004, Wendle-Vos et al., 2007; Bauman et al., 2012). The proportion of a person's friends who participate in exercise is one of the strongest predictors of increased engagement in physical activity and exercise (Plotnikoff et al., 2004). It is also suggested that the effects of social support may be increased if the social group not only offers encouragement but also engages in physical activity with him, for example an individual is more likely to continue an exercise regimen if another member of his social group engages with (Wendle-Vos et al., 2007).

2.2.2 **Environmental**. One of the most commonly studied and arguably the most important environmental factor to consider for daily physical activity levels is the built environment (Saelens et al., 2003; Wendel-Vos, Droomers, Kremers, & Van Lenthen 2007; Ferney, Marshall, Eakin, & Owen, 2009; Saelens & Handy, 2008; Sallis, 2009). The built environment represents all human made components of our physical environment, for example sidewalks, street lighting, buildings, and stairs (Saelens & Handy, 2008). The built environment can be seen as either influential or as a hindrance towards people's levels of physical activity depending on what exists in their environment and how they are able to interact with it. The common finding regarding built environments and physical activity is residents of more walkable neighborhoods (more sidewalks, streetlights, and places to walk to) will engage in more physical activity then residents of less walkable neighborhoods (Salens et al., 2003; Saelens & Handy, 2008). If possible manipulation of the built environment can have a large-scale impact on how people engage in physical activity.

2.2.2.1 ***Internal built environment.*** The built environment also refers to the internal structures of buildings as well. This includes the location and aesthetic appeal of staircases. There is a trend in building practices to feature elevators and hide stairs in the background. In recent years stairs have become simply a means of quick egress in times of emergency (Mcgann, Jancey, & Tye, 2013). One exception to this is in shopping and transit centers where often stairs and escalators are side by side. There is a noticeable trend in the research that stair/escalator interventions tend to be more successful then stair/elevator interventions and the tendency for stairs and escalators to be closer in proximity is potentially one reason. (Grimstvedt et al, 2010; Nocon, Muller-Riemenschneider, Nitzschke, Willich, 2010)

2.2.3 **Psychological.** Psychological factors have a significant influence on both if and how individuals decide to participate in physical activity (Ajzen, 1991; Hays, & Clark, 1999; Bauman et al., 2012). There are many psychological factors to consider when looking at physical activity.

One of the strongest indicators of task completion introduced in Social Cogitative Theory (SCT, Bandura, 1977) is self-efficacy, or an individual's belief about her ability to complete a task successfully Individuals who report high self-efficacy are more likely to engage in an activity than individuals who report low self-efficacy.

Goal setting and self-monitoring are two constructs, found in Control Theory (CT, Carver &

Scheier, 1982). that can be introduced in an intervention to have a positive effect on outcomes. Through goal setting a person consciously decides what they hope to achieve. Once the goal is set a person uses self-monitoring to gage her progress towards a specific goal.

Operant conditioning introduces the concept of rewarding desirable behavior and punishing unfavorable behavior (Skinner, 1963). In current interventions, reinforcing positive behavior in the form of contingent rewards is a form of operant conditioning. Contingent rewards refer to an achievement that an individual receives after a predetermined task is completed (Ryan et al., 1983).

2.2.3.1 Social Cogitative Theory. SCT was born out of social learning theory, first introduced by Alberta Bandura (1977) as an explanation regarding how people learn and acquire new skill or change their behavior. The major addition in SCT is the introduction of the construct of self-efficacy: Self-efficacy refers to an individual's perception that he has the ability to complete a given task. There has long been a relationship between self-efficacy levels and performance on given tasks (people with higher self-efficacy have more success with the targeted behavior). This relationship is important to consider when designing interventions because the intervention might be effective to a different degree for different levels of self-efficacy (Luszczynska, Schwarzer, Lippke, & Mazurkiewicz, 2011; Byrne, Barry, & Petry, 2012).

There are three types of self-efficacy: task self-efficacy, coping self-efficacy, and scheduling self-efficacy (Maddux, 1995). Task self-efficacy refers to an individual's belief that he can complete a given task successfully (Maddux, 1995; Rodgers & Sullivan, 2001; Rodgers, Hall, Blanchard, McAuley, & Munroe, 2002). Coping self-efficacy looks at how confident people are that they can complete a given task in the face of daily barriers, for example being too tired to exercise (Maddux, 1995; Schwarzer & Renner, 2000; Rodgers & Sullivan, 2001). Scheduling self-efficacy is another barrier related construct; however, it deals solely with the barrier of time and planning activities (Rodgers & Sullivan, 2001; Rodgers et al., 2002). Of the three types of self-efficacy, task self-efficacy is the most frequently studied. There are many scales that address self-efficacy in a variety of ways; one scale that addresses the three types of self-efficacy in a physical activity/exercise context is the Multidimensional Self-Efficacy Exercise Scale (Rodgers, Wilson, Hall, Fraser, & Murray, 2008). This scale includes nine items, three items addressing each type of self-efficacy. There is a need to address self-efficacy not only in ideal situations but also in times of difficulty, because that is when people are most likely to stop performing a behavior (Rodgers et al., 2008).

2.2.3.2 Goal Setting. Control Theory (CT) is derived from cybernetics and has taken root in various disciplines (Carver & Scheier, 1982). The main premise in CT is the idea of negative feedback loops that result in self-regulation of a given behavior. It is through these negative feedback loops that goal setting and self-monitoring are introduced. Goal setting represents an ideal that a person is striving to reach or maintain any deviation from this state of completion results in action (Carver & Scheier, 1982). By using a goal as a reference point individuals modify behavior in an attempt to reach whatever they are trying to accomplish (Locke & Latham, 2002). For example an individual who sets a goal of climbing eight flights of stairs each day will view this as the ideal state that they are striving towards. Until he has reached that goal of eight flights of stairs there will be a discrepancy.

Self-monitoring is used by individuals as the method to compare their current state to the goal they are striving for. It is thought that holding oneself accountable rather than having an outside person

keep track is a motivating factor. The main use for self-monitoring is to track the progress of goals and set new goals based on performance to ensure that goals are at the optimum difficulty level (Nothwehr & Yang, 2007). Self-monitoring can take a number of different forms. In physical activity interventions two common forms of self-monitoring are self-report (such as log books or diaries) and objective measure (such as pedometers or accelerometers). There are advantages and disadvantages to both types of monitoring (Patterson et al., 2007). Self-report measure allows for human error and people sometimes over report their activity; however, there is the ability to add context to activities. With objective measure there is the potential to miss activities, stationary bike riding and swimming for example.
In addition, not all objective monitors have a display that is accessible to the wearer and therefore the self-monitoring aspect is lost. Objective measures are often more accurate at reporting the activity that they are able to record (Patterson et al, 2007).

There are three different ways that goals are being used in physical activity interventions: self-set, assigned/prescribed, collaborative (Locke & Lantham, 2002; Harkins & Lowe, 2000; Shilts, Horowitz, & Towsend, 2004). Self-set goals are ones that an individual chooses for himself; these are the most autonomous but can lack accuracy. Assigned/prescribed goals are decided on by an outside party (in the area of healthcare interventions it is usually by a healthcare professional; in this instance participants do not have input regarding the goal. These goals are often more accurate when compared to health recommendations but may not be the correct fit for an individual. Collaborative goals are decided jointly between the outside party and the participant; this type of goal setting is ideal but often only possible in one-on-one counseling sessions (Shilts et al. 2004). Goals are most effective when they are specific, proximal, and difficulty while still being achievable (Locke, Shaw, Saari, & Lantham, 1981). Combining goal setting and self monitoring can lead to an increase in behaviour change (Bravata et al., 2007).

2.2.3.3 *Extrinsic Rewards*. The concept of rewarding desirable behavior and punishing undesirable behavior was most famously developed by Skinner through operant conditioning (1963). Recognition based on behavior is one of the core constructs that gamification ties into programs. The premise of contingent rewards in operant conditioning is the idea that when a positive behavior is performed it is met with something positive in return (not necessary every time but on a pay scale of either fixed or random and time or interval).

Contingent rewards are effective for influencing behavior because if an individual wants to be rewarded (gain achievements) then he is required to complete the target behavior (Goldfield et al. 2006). The key to this is to find a balance between rewards that maintain motivation level towards the target behavior but are not so desirable that they find a way to cheat the system to gain the rewards (Eisenberger & Cameron, 1996). An example of this reward system was demonstrated by Goldfield and colleges (2006), children in the experimental group were required to participate in physical activity in order to earn one hour of television time. The control group could watch television at any time, regardless of physical activity participation. The findings of the study indicate that the use of contingent rewards was successful at increasing the time spend engaging in physical activity in the experimental group; the control group did not increase their physical activity levels (Goldfield et al, 2006).

2.3 Physical Activity Interventions

The history of physical activity interventions is extensive and varies significantly depending on the target population and the behaviour the researchers are trying to influence. To determine if there was a need to proceed with this study a review of literature was conducted. There are distinctive gaps in the literature in the areas of gamification as well as stair climbing interventions that this study will address.

2.3.1 Workplace interventions. In today's society large workplaces often have some form of health and wellness program (Consulting, M. H. R., 2007; Capps & Harkey, 2008; Morrison & MacKinnon, 2008). These programs target employees' mental and physical health, and sometimes include a physical activity component. Because these programs already exist in the workplace many physical activity interventions are introduced as corporate challenges or programs. Evidence suggests that these interventions can have significant effects on health related behaviors (Proper et al. 2003; Cook, Billings, Hersch, Back, & Hendrickson, 2007; Dugdill, Brettle, Hulme, McCuskey, & Long, 2008; Conn, Hafdahl, Cooper, Brown, & Lusk, 2009; Gilson et al., 2013; McAlpine, Manohar, McCrady, Hensrud, & Levine, 2013).

Two forms of interventions that commonly occur in workplace are information-based interventions and action-based interventions (Proper et al. 2003; Conn et al., 2009; Gilson et al., 2013). Information-based interventions can be delivered in print format, presentation format, or web-based format. These interventions provide participant with information about how and why they should change their behaviour. Interventions taking this form do show modest changes in behaviour (Proper et al. 2003; Cook et al, 2007; Dugdill et al., 2008; Conn et al., 2009). The second and more successful of the two forms of interventions includes a call to action. There is often still an information component, however it is followed up with a challenge or an activity. These activities can take many forms. One example is the Walk@Work program delivered to university employees in Australia, Canada, Northern Ireland, and the United States (Gilson et al., 2013). Employees were given pedometers and tasked with increasing their daily steps by 1000 steps/day every two weeks for a six-week period. The significant finding from this study was that participants who were the least active at the beginning of the study increased by the largest margin adding almost double the amount of steps their active counterparts added. This finding is encouraging because it gives evidence that action based interventions can have significant results for people of all activity levels (Proper et al., 2002; McAlpine et al., 2007; Gilson et al., 2013).

2.3.2 Stair climbing interventions. While it has long been know that there is an inverse relationship between stair climbing and risk of heart disease (Paffenbarger et al., 1978), there is a lack of interventions that have focused on changing stair climbing at the level of the individual. The majority of the work in the area of stair climbing has revolved around point of decision prompts and trying to influence people to choose the stairs over the elevator (Kerr et al., 2001; Olander et al., 2007; Webb & Eves, 2007; Lewis & Eves, 2012). The studies conducted in this area use some form of motivational poster or banner to encourage the change in behavior. The consensus of findings in this area is that point of decision prompts can be effective if they are placed in an area that is easily seen by the targeted individual and does not involve complicated messaging; however the effects are often short term and diminish once the signs are removed. (Kerret al., 2001; & Olander et al., 2007).

The measurement of stair climbing is of the areas has been lacking in research. As demonstrated by the literature review in the past there have only been two types of monitoring (direct observation and self report). By incorporating an objective measure that does not involve a researcher having to count behaviour the types of interventions that can be conducted increases. There is a need to focus on interventions at the individual level, which uses stair climbing as the dependent variable rather than the independent variable. For this to be done an objective measure needs to be used. Past studies have shown that pedometers are not a reliable method for measuring stair climbing behaviour (Ayabe, Aoki, Ishii, Takayama, & Tanaka, 2008; Leicht & Crowther, 2009). Recent advances in technology which include the availability of physical activity monitoring devices that include an altimeter function to record stair climbing makes this advancement in research possible.

2.3.3 Web-based interventions. The use of websites as an intervention has appeal because of the constant availability (participants can engage whenever is convenient) and the cost effectiveness of running a large-scale intervention (the cost is relatively stable regardless of the number of participants). Web-based interventions are becoming increasingly more popular because of this ease of use component, however these interventions are not without their challenges.

Some studies that have used web based interventions report low engagement rates; approximately 22% of participants logged onto the website once and only about 7% logged on regularly (Vandelanotte, Spathonis, Eakin, & Owen, 2007; Hansen, Grønbæk, Helge, Severin, Curtis, & Tolstrup, 2012). However, when participants were grouped by their website engagement levels there was a difference found in activity levels (Hansen et al. 2012). There is some evidence that suggests that engagement with a website has an effect on the success of the program. If this is the case then understanding what features of the website promote engagement and retention is important to consider.

The most engaging elements of the website tend to be the interactive components such as, videos, logging, personal records, and links to click on (Davies et al., 2012). A new approach to web development is referred to as Web 2.0, the differentiating feature of this type of website design is the inclusion of user-generated content. User-generated content can take many from including message boards, blogs, and uploaded photos (Thackeray, Neiger, Hanson & McKenzie, 2008). An additional way to increase the effectiveness of web-based interventions is to include moderating factors such as sample size, baseline screening, and some type of education (Davies et al., 2012).

Due to web-based interventions being relatively new to the health promotion world it is important to determine if they can provide similar outcome to traditional interventions. To find out if these designs offer similar outcome statistical equivalency testing is used. Statistical equivalency is an analysis used to determine if two variables are significantly similar and the findings suggest that the web-based version of the intervention was just as effective as the face to face intervention (Steele, Mummery, & Dwyer, 2009). Overall web-based interventions appear to be an effective medium to promote changes in physical activity levels. Although larger effect sizes are found with short-term behaviour change interventions, there is evidence to suggest that long-term change is possible (Vandelanotte et al., 2007; Davies et al., 2012; Davies et al., 2012).

Web-based interventions can be used to target a variety of different populations on an individual, group, and population level. Successful interventions have been carried out in the areas of type II diabetes (Kim & Kang, 2006), cardiac rehabilitation (Zutz, Ignaszewski, Bates, & Lear, 2007), and sedentary individuals (Kypri & McAnally, 2005). A successful population wide walking intervention that was carried out in Australia largely relied on the use of a website as a means of tracking and disseminating information – the results garnered from this program provide large evidentiary support for the use of web-based interventions as a helpful tool to change behaviour (Mummery, Schofield, Hinchliffe, Joyner, & Brown, 2006).

2.3.4 Gamified interventions. The scope of the literature review for gamification was limited to studies that specifically referred to gamification or gamified interventions. Gamification can be simply described as trying to use the elements present in games (often video games) that increase user engagement and enjoyment in other situations where user engagement is historically a problem – physical activity interventions for example (Garris et al., 2002; Deterding, Dixon, Khaled, & Nacke, 2011; & Muntean, 2011). Gamified elements include story lines, badges/achievements, competition, leaderboards, and interactive progress maps. Most of the background research in this area is from the field of cybernetics (Muntean, 2011), game design (Flatla et al., 2011), and information technology (Muntean, 2011) - the transition to other areas such as the health care field is still in its infancy. As a result of gamification for health promotion purposes being in such an underdeveloped stage and there is little definitive evidence of the effectiveness of these interventions. However, despite the lack of physical activity interventions there is still evidence that gamified physical activity interventions could be effective (Mutean, 2011; Peng et al., 2012; Hamari, Koivisto, & Sarsa, 2014)

The initial use of gamification in health care interventions focused on the development of active video games to incorporate the target behaviour into the game concept. An example of this method is an active video game (exergame) to explore how psychological needs and motivation can be satisfied (Peng et al., 2012). An active video game requires the player's body to move in order to interact with what is happening on the screen (for example Wii and Kinect). In one study the researchers developed a game to target physically inactive youth who engage in video games. The novel concept in this game that makes it different from the exergames that already exist is the game narrative (similar to the story line present in traditional video games). Autonomy-supportive features were added to the game to increase a sense of autonomy; they included having the player customize their character, having the player choose which skills increased when they found treasure, and giving the player a choice of dialogue when interacting with other characters in the game. Three features were designed to address the construct of competence. If a player failed a challenge the next challenge would be easier; however, if the player succeeded then the next challenge would be more difficult. Second there was a heroism meter that would indicate to a player how well they were doing at any given time. Also there were various achievements that a player could unlock as the game progressed. In the control group of this study all of these features were disabled. Both the autonomy-supportive and competence-supportive features were significantly positively related to all of the dependent variables except for effort (Peng et al. 2012). This game represents the only intervention of this type that has been completed in the area of physical activity that the authors are aware of. Similar interventions in that area of nutrition also provide positive evidence towards the use of game elements to promote changes in health behaviours (Peng, 2009). The results of this study show that there is room for the integration of game components into physical activity interventions.

There are other studies currently underway using similar gamified constructs (rewards for increases in physical activity and reductions in sedentary time as well as the integration of social aspects to target behaviour in interventions (Ahola et al., 2013). Smartphone applications are also being designed using a gamified framework (Bielik et al., 2012). Additional gamified smartphone applications that are similar to the website proposed in this paper in terms of the game features that are incorporated are commercially available (examples include Striiv and Nike+), however they are designed by corporate bodies with the intent of commercial gain. There remains a need to study and understand the elements of gamification in physical activity interventions.

2.4 Conclusion

This review of the literature garnered support for the investigation of a web-based, gamified intervention targeting stair-climbing behaviour in individuals. The health benefits of physical activity are well documented and therefore there are health gains to be made by influencing behaviour change in this area. Considerations should be made with regard to the correlates of physical activity when designing interventions. The constructs of social support, psychological factors, and the built environment have a proven impact on an individual's decision to engage or not engage in physical activity. Interventions that are grounded in psychological theory are more effective than atheoretical interventions (Michie, Johnston, Abraham, Lawton, Parker, & Walker, 2005).

The study conducted for this paper fills a number of gaps in the literature. Due to the lack of an objective stair-climbing measure the interventions in this area have been limited to group observational studies and experiments where the daily stairs climbed was the independent variable. The availability of an altimeter that not only tracks and records flights of stairs climbed represents an exciting new opportunity in this area. Due to the advance in technology we were able to conduct a study that objectively measures individual stair-climbing behaviour with a minimal amount of inconvenience – this allows for higher external validity because the results come from a more natural environment. The second gap in the literature that this study fits into is as a non-video game gamification intervention. The majority of academic work in the area of gamification does not differ significantly from the traditional video games that they are based upon. While there currently are commercially available gamified websites and smartphone applications the majority of these are designed by either fitness companies or computer science professionals. The consideration of different types of physical activity interventions led to the decision that a gamified web-based stair climbing intervention was a novel and potentially effective way to increase the daily flights of stairs people climb.

Chapter 3: Methods

3.1 Study Design

This study was a quasi-experimental non-equivalent control group study conducted using a Solomon Four-Group design. The purpose of this design is to determine and control for any effect that a pre-test may have on the outcome of results. This is achieved by splitting the traditional two groups (intervention and control) into four groups; intervention with pre-test, intervention without pre-test, control with pre-test, and control without pre-test. In the case of this study participants either participated in a two week baseline (pre-test) or started the study directly on the website (no pre-test).

This study is also being limited to a web-based intervention with no true control group. There is evidence to support that web-based interventions can be statistically equivalent (Steel, Mummery, & Dwyer, 2009). By having the control group also use a website, we can control for the effect of web-based interventions and will be able to determine the effects of gamification.

3.2 Participants

Participants were recruited from two work places located in downtown Edmonton, Alberta. The sample included both men and women who work in an office setting and therefore were likely to have a sedentary job. A third worksite affiliated with the control office was added to balance the number of participants in each group. Two of workplaces that participated in this study were both located in office buildings in Edmonton, Alberta. The original two worksites are on the top floor of the bank of elevators that services their floor (the 15th and 24th floor). Employees of both workplaces are located on the same floor as co-workers they interact with and washrooms are located on the floor that they are working; despite this employees do have access to other floors. The third workplace is located in an office building with three floors and employees interact with co-workers on all three floors. The stairwells of all three buildings are relatively similar as shown in Figures 1, 2, & 3. All three stairwells were closed in, lit, and free from debris or foul odours.

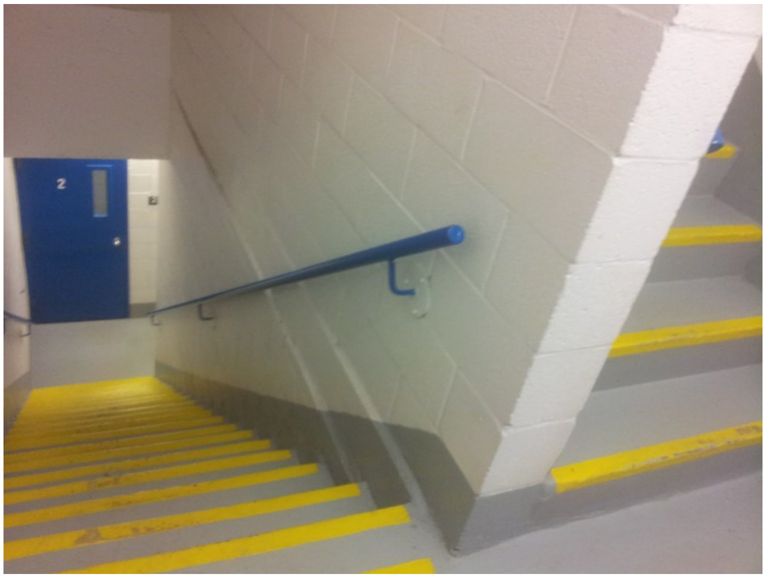

Figure 1.0. Stairwell of the control group workplace

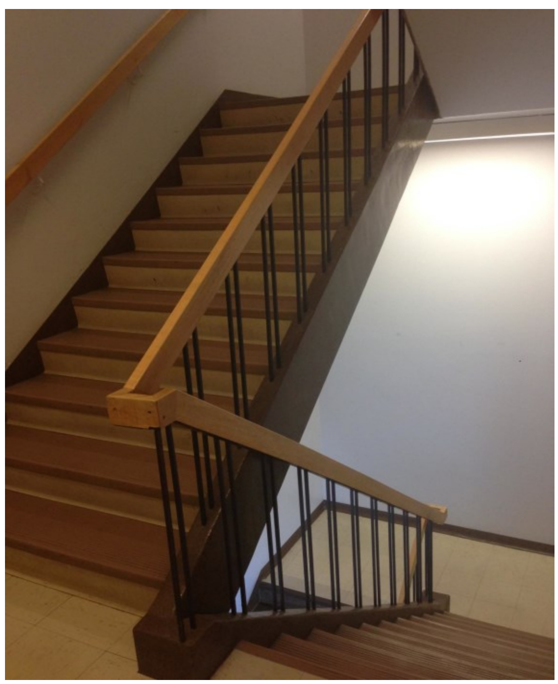

Figure 2.0 Stairwell of additional control group worksite

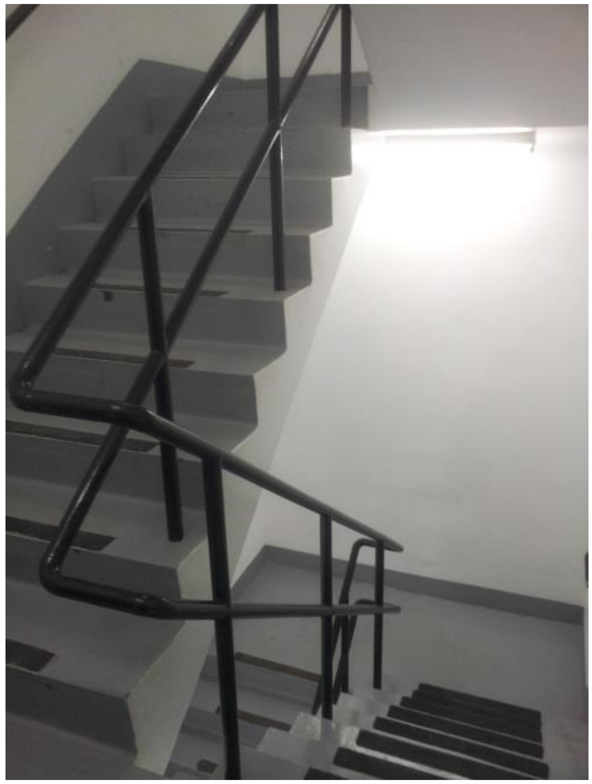

Figure 3.0. Stairwell of the intervention group workplace.

3.2.1 Recruitment and eligibility criteria. Workplaces were approached and invited to take part in this study. A workplace information letter was emailed to potential participating workplaces (See Appendix A.). Once two workplaces were identified an information letter was sent out to all of the employees, through a corporate representative within the company, informing them of the study and inviting them to participate. The first 60 employees from each workplace to respond were included in the study (See Appendix B for consent form). Once participants were recruited to the study the Physical Activity Readiness Questionnaire (PAR-Q, Canadian Society for Exercise Physiology, 2002) was used to determine if the potential participant is physically capable of being part of the study (See Appendix

C.). If participants failed the PAR-Q they were be excluded from the study and the next person on the list was invited to replace them. In addition to completing the PAR-Q eligibility criteria included that all participants must be full time employees not taking vacation during the study who were over the age of 18 and have a work computer with internet access.

3.3 Sample Size

A power analysis was completed to determine the sample size required to achieve a medium effect size at an alpha level of .05 when conducting a 2X2 ANOVA. It was estimated that 56 participants were needed for each group for a total of 112 participants (Cohen, 1992). This sample size calculation is based on evidence that shows web-based interventions have the ability to produce medium effect sizes (Wantland, Portillo, Holzemer, Slaughter, & McGhee, 2004).

3.4 Instruments

The Fitbit One (Fitbit Inc.) is a tri-axial accelerometer with an altimeter to measure flights of stairs climbed. It was be used as an objective measure to record daily flights of stairs climbed by the wearer. Currently the Fitbit One is the only available altimeter that records elevation in terms of flights of stairs. A previous study found the Fitbit One is valid and reliable for measuring stairs climbed (Fairbairn & Mummery, 2013). The altimeter function records flights of stairs by monitoring physical activity during changes in elevation (a change of 10 feet in elevation is equal to 1 flight of stairs). Both groups wore the Fitbit One for the duration of the study.

The PAR-Q (Canadian Society for Exercise Physiology, 2002) was used as a screening device to ensure that all individuals who are participating in this study are physically able to meet the demands of physical activity. The PAR-Q is a seven-item inventory that assesses an individual's physical ability to engage in an activity without being exposed to an elevated risk of harm.

The MSES will be used to determine participant's levels of self-efficacy for stair climbing (See Appendix D). There are 9 items on the MSES that address three different types of self-efficacy (task, scheduling, and coping). Participants are asked to rate how confident they are that they can complete a given behavior (in this case stair-climbing) on a scale from 0%-100%. This scale has been proven valid and reliable (Rodgers et al., 2008). Demographic information (age, gender, weight, education status, and SES status) was collected at the same time as the MSES.

3.5 Validation of the Fitbit One.

The objective measure being used for this study is a new piece of technology that had previously not been validated for the stair climbing function. Before the Fitbit One was used in this study reliability and validity testing was conducted by the authors. The formula used by the Fitbit is that a flight of stairs is registered by the device for each ten-foot increase in elevation. A course was setup across two staircases that included 20 flights of stairs. A total of 11 devices were tested across 66 participants. Each participant was randomly assigned a device and instructed to walk the course, when they completed the course the output from the Fitbit was recorded and then compared to the actual amount they climbed (20). To test discriminate validity participants also rode a total of six flights in an elevator. The results of the elevator test showed that none of the devices registered any flights of stairs during the elevator ride; this is a positive result because it demonstrates the devices ability to differentiate between stairs and non-stairs.

The results of the main validity and reliability test demonstrated a positive result. The range of flights that the devices recorded was 19-21. The internal consistency within the devices was high $\alpha = .86$, seven of the eleven devices were accurate 100% of the time. The percent agreement across devices was also high at 94%. The absolute percent error was also well within the acceptable range (APE: -0.23 ± 1.37). Based on these results we are confident that the altimeter function of the Fitbit One is a valid and reliable measure for stair climbing.

3.6 Intervention.

As part of the intervention two websites were designed. The first website is a generic website that simply provides the users with numeric feedback regarding how many flights of stairs they climbed. The second website is the gamified website which has game design elements built into it. The story line of the website was a challenge titled “Climb Mt. Athabasca.” Participants’ flights of stairs were converted into meters to reflect the elevation of Mount Athabasca, one of the mountains in the rocky mountain range of Alberta. This challenge has been set up to match the health recommendation for flight/week. There are a total of 220 flights required to complete the challenge and it takes 4 weeks if participants complete the recommended 55 flight/week. During the intervention participants in the intervention group were able to track their progress up the mountain visually through an interactive map function as shown in Figure 4. In addition badges/achievements were awarded to participants based upon progress and interaction with the website shown in Figure 5. Functions present on the website also allowed users to view their daily progress and self-monitor against set goals shown in Figure 6. Participants were working individually to complete this challenge but because they were all participating in the same challenge there was be a leader board to provide feedback on participants' ranks shown in Figure 7. The competition element is another gamified feature added to the website.

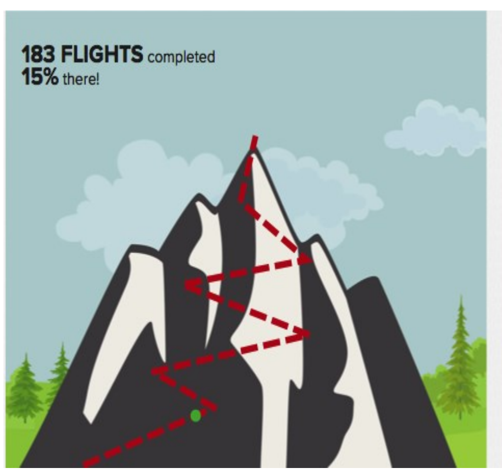

Figure 4. Screen shot of the progress map.

Figure 5. Screen shot of badges available.

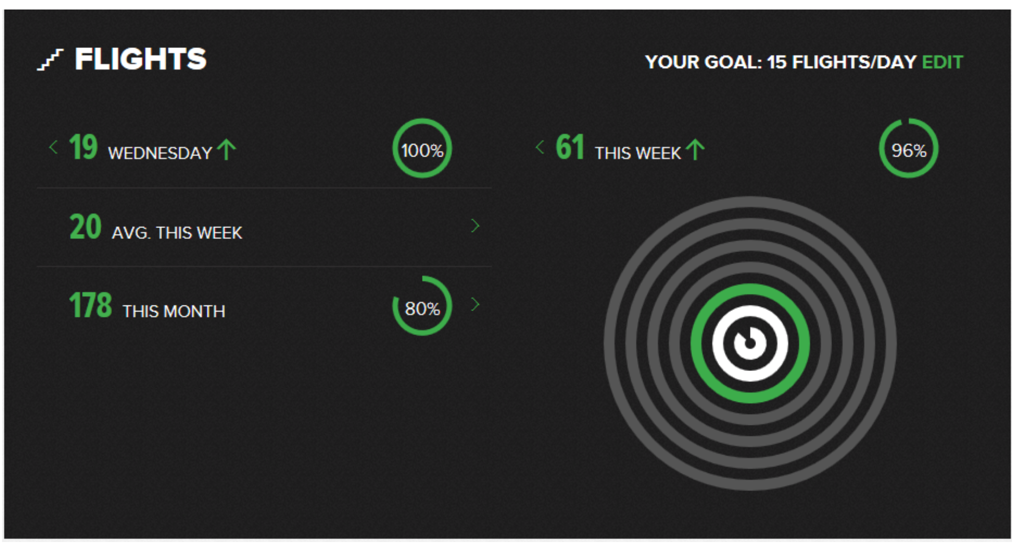

Figure 6. Screen shot of the visual progress feedback provided.

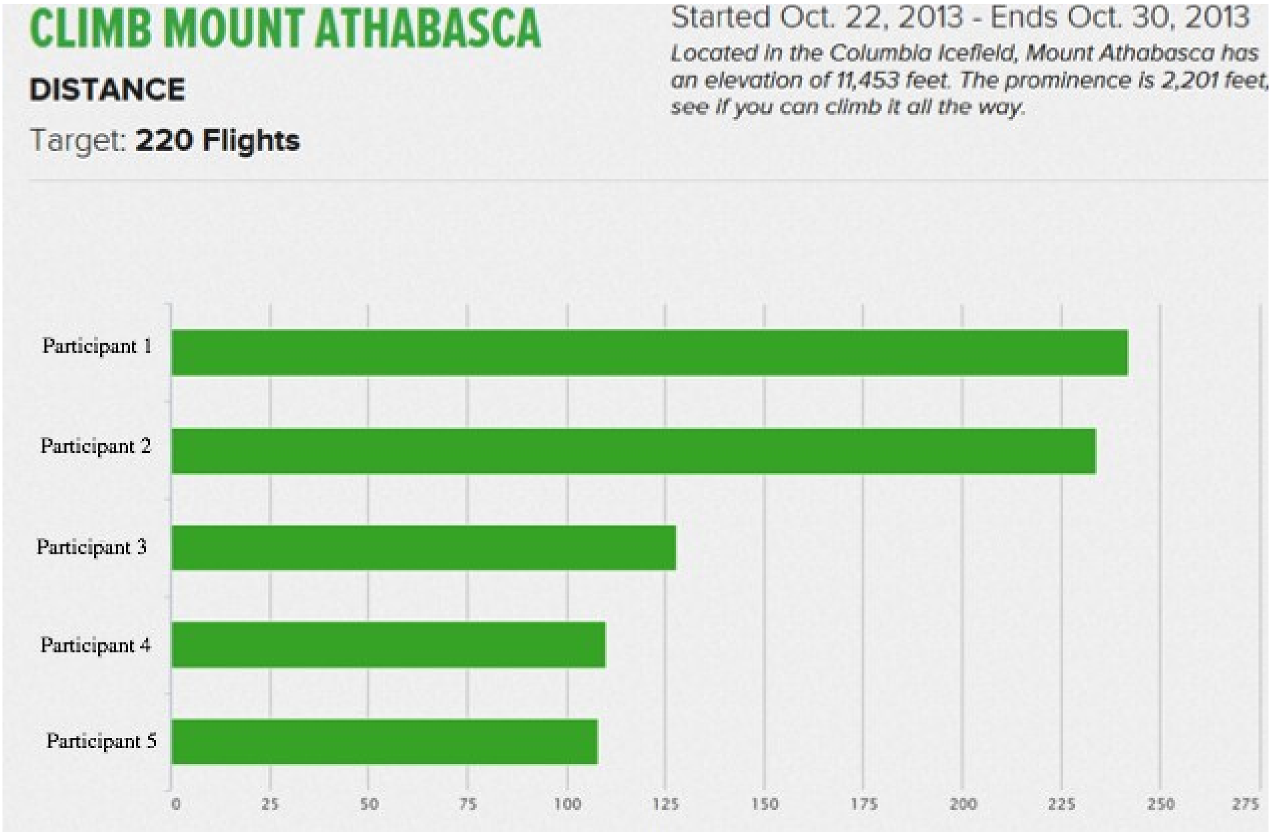

Figure 7. Screen shot of the leader board

All four of the aforementioned gamified features were added to increase engagement and provide users with feedback to aid in self-monitoring and goal completion.

The user interfaces of both websites require users to manually enter their flights of stairs each night (as it appears on the Fitbit). To ensure that the information being recorded is accurate and to provide a backup against participants forgetting to record their steps a day the devices were synced to the factory website that only the researchers have access. If there was a discrepancy between the two outputs the factory website numbers will be used because those are a proven accurate measure. The factory website was also used to collect baseline data.

Engagement with the website was tracked with the intervention group. A background analytic software was present that provided information on the frequency that participants are logging flights.

3.7 Procedure

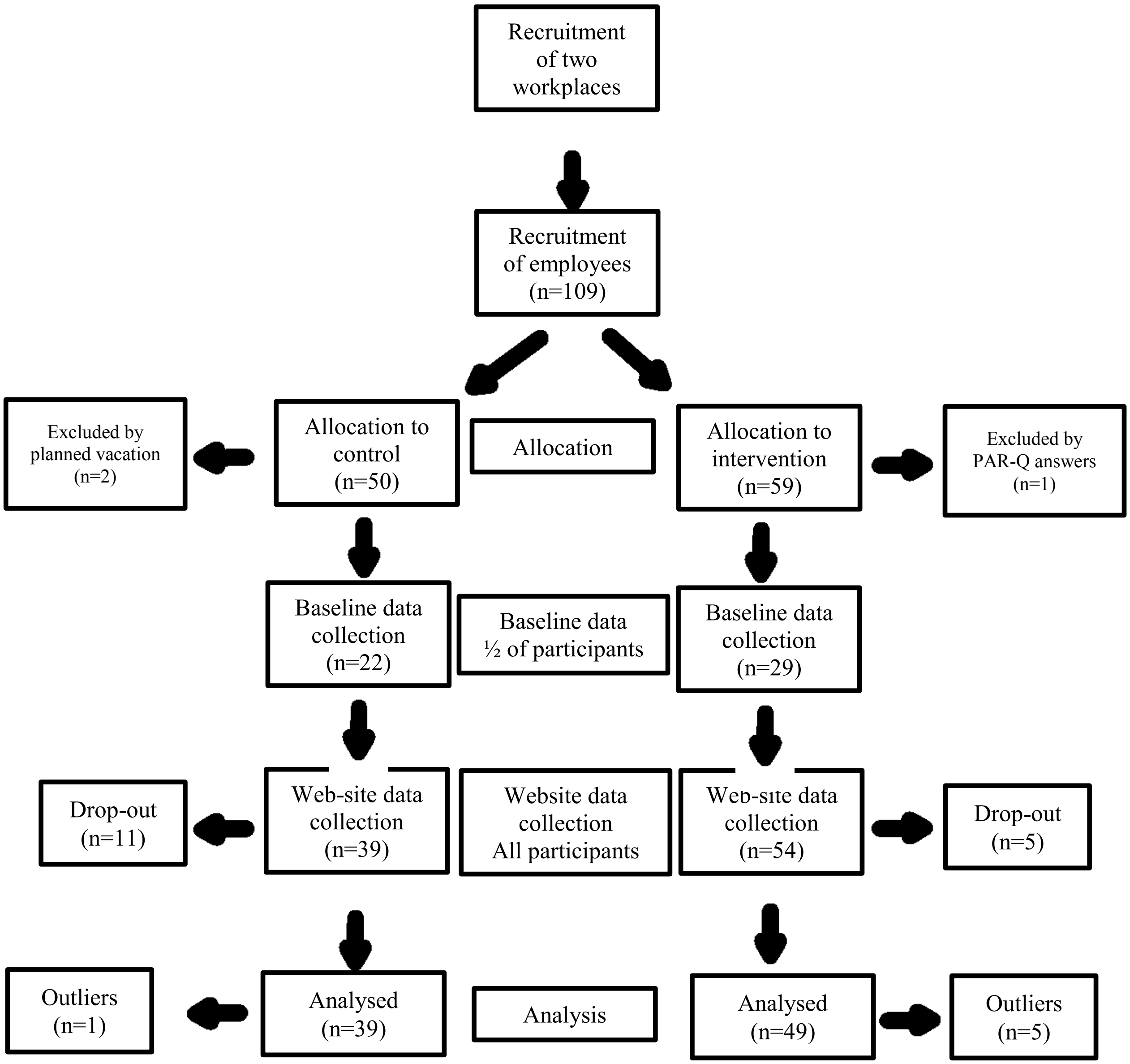

Figure 8. CONSORT Diagram.

Two workplaces in Edmonton were recruited to participate in this study. The first workplace to respond was assigned to be the control group and the second workplace to respond was assigned to be the intervention group. The PAR-Q was then administered on the first 60 interested employees to ensure that participants are physically healthy enough to take part in this study.

At the onset of the study (the day before the baseline data collection began) a researcher gave a briefing to the first 30 employees in each group to instruct them about how to wear and use the Fitbit devices. The baseline data collection was used as the pre-test. Both groups had access to an unblinded Fitbit One for the duration of the study (6 weeks for participants in the pre-test condition and 4 weeks for the participants in the no pre-test condition). Participants were instructed to wear the monitor on either their hip or in the front middle portion of their bra (as recommended by the manufacturer) from the time they began their morning commute until they end their commute after work for the duration of the study. The computers of all participants were set up so that the monitors will automatically sync data whenever the monitoring device is within 20 feet of the computer. The devices synced to the factory website: this was used solely by the researchers to track data, participants were not able to access the Fitbit website because they did not have the login details. Participants were also given a charger for the monitoring device and were advised to charge it on Wednesdays while they are seated at their desk. On the last day of the baseline data collection the researcher returned to the work place to administer the MSES and give a tutorial on how to use the website (generic website for the control group, and the gamified website for the intervention group) at this point the additional participants (those in the no-pretest condition joined the study).

Participants were encouraged to check the website at least once a day – the engagement with the website was monitored with an internal software feature to that logs how many times each participant records data on the website. The engagement tracking software was only available with the intervention website. Participants in both groups were also given suggestions on how to increase the number of stairs they climb; these suggestions included using the bathroom or lunchroom on a different floor and getting off the elevator an floor early and walking up the last flight of stairs.

Due to the nature of using two different work places there is potential for inequality between the two groups. To determine if the groups are similar at baseline the first two weeks of the study will be used to collect baseline data. If the work places are found to be unequal then difference scores (between baseline and intervention) will be compared instead of raw data.

3.7.1 **Outcomes.** The independent variable in this study is the presence or absence of gamification to the participants. The rational for having a two group design with the control group also using a website is to allow for the ability to discount any increase in activity that is due to engagement with a website as opposed to the use of gamification.

3.7.1.1 ***Primary outcome***. The dependent measure in this study stair climbing behavior. This will be measured by the flights of stairs climbed by participants during the last week of baseline and the last week of the website phase. The primary outcome that the researchers are concerned with is does the addition of a gamified component help to increase a target behavior.

3.7.1.2 ***Secondary outcome.*** The secondary outcome for this study has to do with engagement;

more specifically is engagement with the website related to more stair climbing.

3.7.1.3 ***Tertiary outcome.*** The tertiary outcome of this study deals with the influence of self-efficacy on success in the intervention. The scores from the MSES will be analyzed to determine if people who report higher self-efficacy climb more stairs each week and if people who report low levels of self-efficacy climb fewer flights of stairs each week.

3.8 Data Analysis

The Statistical Software Package for the Social Sciences 20th edition (SPSS Statistics 20) will be used to complete all analyses.

The statistical treatment for the primary outcome, the results of the Solomon four group design, is based on the recommendations of Braver and Braver (1988), who propose a method of analyzing data while still maintaining power. The first statistical test that is preformed is a factorial ANOVA (pre-test yes or no) (intervention yes or no), this test is done to determine if a pre-test sensitization is present. For the baseline group data will be reported from the second week of baseline and the last week of the study; for the non-baseline group data will be reported from the last week of the study only. The second test that is conducted is a main effect ANOVA to determine if there is a treatment effect present.

The analysis for the secondary outcome was be determined using a using a Pearson Product Moment correlation to determine if there is a relationship between engagement with the intervention website and the number of stairs climbed. For this analysis the engagement will be characterized by the number of times a participant logged their data on the website.

The tertiary analysis will be done using a Pearson Product Moment correlation. Using the results of the MSES an average score for each of the three types of self-efficacy will be calculated by adding the percentages together for each relevant question and then dividing by the number of questions for each construct. The average scores and the number of stair climbed will then be compared to determine if there is a significant correlation for any of the constructs.

3.9 Conclusion

This study seeks to fill a void in the literature by introducing gamified elements into physical activity interventions. Our hope is that this design will prove to be an effective method of behaviour change and can be put to use in future studies. Other unique features of this study will also add to the literature. One of the largest gaps in the literature is in regards to looking at stair climbing as a dependent variable or a behaviour that we could seek to modify. By including Fitbit devices in the study we are able to monitor stair climbing on an individual level. The other side of this is that the Fitbit is a commercially available monitor that participants would be able to find once the study is completed if they choose to continue monitoring their stair climbing. Because the effects of this study may be maintained after the researchers have been removed lasting behaviour change is possible.

Chapter 4: **Paper for Publication**

Abstract

The use of gamification in health promotion is a newer method that is being utilized to raise engagement in interventions to keep more participants involved to maximize the effectiveness of the intervention. As this is a new method very limited research has been conducted to determine to what extent gamification is effective, if at all. The results of this study seek to help fill this void.

Methods: A total of 109 participants were recruited from two work places in Edmonton, Alberta (three work sites). The first work place was allocated to the intervention group and the second work place (two work sites) was allocated to the control group. A Solomon Four Group design was used with a two-week baseline used in place of a pretest. The intervention group completed a four weeks of monitoring their stair climbing activity using a Fitbit One and recording their data on a gamified website (www.UWALK.ca). The gamification was in the form of a challenge whereby participants virtually climbed a mountain while climbing stairs in real life. The control group also completed four weeks of monitoring their stair climbing activity using a Fitbit One but they recorded their data on a generic self monitoring website with no additional feedback.

Results: The primary outcome of the Solomon Four Group design showed a significant increase in stairs climbed by the intervention group, $F(1, 33) = 6.339$, $p = .017$. The secondary outcome determined a non significant correlation between engagement with the website and number of stairs climbed, $r = .251$, $p = .067$. The tertiary results showed a non-significant correlation between task self-efficacy and stairs climbed, $r = .097$, $p = .357$. A significant correlation was found for both coping and scheduling self-

efficacy, $r = .251$, $p = .039$ and $r = .237$, $p = .023$ respectively.

Conclusion: The results of this study are encouraging with respect to the use of gamification as a tool to maximize the effectiveness of interventions. Due to the study design used in this study we were able to isolate the effects of gamification and can say that there is a place for gamification within web-based interventions.

Introduction

The use of technology to enhance health promotion campaigns has become more widely accepted in recent years. The research has shown that web-based interventions are effective as long as participants remain engaged with the web-site (Hansen, Grønbæk, Helge, Severin, Curtis, & Tolstrup, 2012). The problem with this is currently web-based interventions have a low adherence rate (Vandelanotte, Spathonis, Eakin, & Owen, 2007; Hansen et al., 2012). From this arises the need to increase engagement and participant retention to help maximize the effectiveness of web-based interventions. One such method is gamification; adding engaging elements from games to situations that they are not normally found and situations where engagement is typically lacking (Muntean, 2011; Garris, Ahlers, & Driskell, 2002). Examples of gamified elements can include story lines or challenges, leaderboards, and rewards or achievements (Deterding, Dixon, Khaled, & Nacke, 2011). The reward elements came in the form of extrinsic rewards; participants are rewarded for either engagement or positive behavior (Deci, Koestner, & Ryan, 1999).

The use of gamification in physical activity interventions is in its infancy and thus requires research to determine if it is a worthwhile theory (Hamari, Koivisto, & Sarsa, 2014). Gamification has been used successfully in other health areas such as nutrition (Richards, 2013) and drug compliance (de Oliveira, Cherubini, & Oliver, 2010) these finding lend support that gamification could be an effective method in increasing engagement and influencing behavior change depending of the type of implementation (Hamari et al., 2014). In the area of physical activity gamification has been successfully used in exergames (Peng, 2009).

Another challenge facing health promotion campaigns is the ability to make meaningful changes that result in health benefits. To address this challenge in this study stair climbing is used as the target behavior. Stair climbing makes a compelling target behavior because there is evidence that climbing a minimum of 55 flights of stairs each week can lead to a lower risk of cardiovascular diseases (Paffenbarger, Hyde, Wing, Lee, Jung, & Kampert, 1993). In an office environment during a typical workday there is the opportunity for employees to take the stairs in place of an elevator or escalator. Stair climbing interventions historically have not been conducted on an individual level (Kerr, Eves, & Carroll, 2001; Olander, Eves, & Puig-Ribera, 2007; Lewis, & Eves, 2012; Webb, & Eves, 2007); however with recent advancements in technology valid and reliable objective measures for stair climbing have become available and individual interventions have become possible (Fairbairn, & Mummery, 2013).

Methods

Study Design

This study uses a Solomon Four Group Design to control for the possibility that the introduction of the novel monitoring devices (Fitbit One) may influence the outcome of the study. Participants were allocated to either the intervention or control condition; from there participants were allocated to either a baseline or no baseline condition. Based on this the four groups are as; control with baseline, control without baseline, intervention with baseline, and intervention without baseline.

Participants

Two work places in Edmonton, Alberta were recruited to participate in this study; from there employees were recruited (n = 45, control and n = 59, intervention). The workplaces were used in this study were office buildings that were serviced by both stairs and an elevator. The employees were located on the third, ninth, or twenty-seventh floor of their respective buildings. Demographic information on the participants can be found in Table 1. The participants for this study were also predominantly Caucasian (~80%).

Table 1

Demographic Information for Participants

		Control Group	Intervention Group	Total
Total		40	54	
Gender	Male	8	11	19
	Female	32	43	75
Age	18-35	14	17	31
	36-45	10	15	25
	46-55	8	17	25
	55+	8	3	11
Marital Status	Single	10	13	23
	Common-Law	3	6	9
	Married	24	26	50
	Separated	0	4	4
	Divorced	3	0	3
Education Level	High School Diploma	2	1	3
	Some College	3	15	18
	Trade/Vocational	4	4	8
	University	31	32	63

Intervention

The website that was used for this study was designed as part of a new provincial walking program in Alberta. The UWALK website was designed with gamification in mind and has multiple elements built in. For this study a four-week stair climbing challenge was chosen to be the test challenge for this study. During this challenge participants virtually climbed Mt. Athabasca (a mountain in the Rocky Mountain range in Alberta). There are multiple gamified elements built into the UWALK website; the primary element that was used in this study was the story line and challenge. Additionally participants would earn achievements as they reached certain milestones; there are both singular milestones, such as climbing ten flights in a single day and cumulative milestones, such as climbing 500 flights of stairs total. A leader board and a progress bar were displayed to show how participants raked in comparison to other participants and how close they were to completing the challenge.

Procedure

On the day prior to the beginning of the baseline testing participants in groups 1 or 3 attended an orientation meeting where they returned their completed PAR-Q and received their Fitbit and instructions on how to wear and charge it. Separate meetings were held for control and intervention participants. Participants were instructed to wear the Fitbit from the time the left for work in the morning until they returned home from work or reached there first non-work related stop (this was considered the end of their commute). By having the participants wear the Fitbits for this period of time we are able to account for their movements during their workday including their commute. Fitbit accounts were set up for each of the participants; these accounts were controlled by the researcher and were not accessible by participants. Participants were instructed to sync their Fitbits by plugging the wifi dongle into their computer and ensuring the Fitbit came within 20 feet of the dongle each day. Baseline data was pulled off of the Fitbit website by the researcher.

On the last day of the two-week baseline all participants met for a second orientation meeting. In this meeting participants completed a version of the MSES (Rodgers, Wilson, Hall, Fraser, & Murray, 2008) that has been modified for stair climbing; the survey also included demographic questions. Participants were then instructed on how to log onto and use the study website, the UWALK website for the intervention group and the generic monitoring website set up for the control group. Participants from both conditions were told the public health recommendation of 55 flights per week (Paffenbarger et al., 1993); the researcher also gave the same suggestions to both groups of how to increase the number of stairs they are climbing. Some examples of suggestions that were given were to get off the elevator a floor or two early and use the bathroom or eat lunch on a different floor. Participants were instructed to mark down their daily flights from the Fitbit at the end of their daily commute and then enter them on the website either that night or at work the next day. At the end of the four week website phase the both groups attended follow up meetings where they were debriefed on the study; the control group was given the opportunity to retain the Fitbits for an additional four weeks to participate in the UWALK gamified challenge.

Data Analysis

The primary analysis for this study will follow the protocols suggested by Braver and Braver (1988). The first step if to complete a factorial ANOVA to determine if there is a pre-test effect present. The second step is to complete a main effect ANOVA to determine if a there is a treatment effect. If the results of the factorial ANOVA are negative and the main effects ANOVA are positive then you can conclude that your treatment has an effect regardless of the presence of a pre-test. If the main effect ANOVA is non-significant then an ANCOVA is preformed to using the pre-test scores as a covariate. A T-test is also preformed on the non pre-test group; the results of the ANCOVA and t-tests are combined to form a $z_{(meta)}$ score.

The secondary and tertiary outcomes of this study are both Person Product Moment Correlations. For the secondary outcomes engagement levels will be analyzed with behaviour outcomes to determine if a significant relationship exists. The tertiary outcomes will use the results of the MSES scores categorized into the three types of self-efficacy and then compared to the behavior outcomes to determine if there are any relationships present.

All statistical analyses were completed using the Statistical Package for the Social Sciences (SPSS) version 22.

Results

Intention to treat (ITT) principles were applied to this study to try and account for the results of participants who did not complete the study. The method that was used for this study was last observation carry forward (Hollis & Campbell, 1999).

T-tests were completed between all relevant groups to determine equivalency at key times. No significant differences were found between any of the groups at any time; pre-test intervention and control, $t(35) = 0.022$, $p = .982$, pre-test and no pre-test for the intervention group, $t(47) = -0.183$, $p = .856$, and the pre-test and no pre-test groups for the control condition, $t(16) = -0.116$, $p = .909$.

The results of the factorial ANVOA was non-significant for the pre-test condition, $F(1, 87) = .561$, $p = .456$; there was also no significant interaction effect, $F(1, 87) = 1.034$, $p = .312$. Due to the non-significant interaction a main effect ANOVA was subsequently conducted. The results of the main effect ANOVA showed a significant treatment effect, $F(1, 33) = 6.339$ $p = .017$; there was not a significant interaction effect, $F(1, 33) = 2.313$, $p = .138$. The descriptive statistics for the primary outcome is shown in Table 2.

Table 2.

Descriptive Statistics for Average Daily Stairs Climbed

	Control Group		Intervention Group	
	Pre-test	Post-test	Pre-test	Post-test
Mean	14.62	12.83	11.26	15.54
Standard Deviation	7.85	6.50	3.82	6.08
Range	21.14	25.75	16.55	21.00
Minimum	5.86	2.25	2.25	7.00
Maximum	27.00	28.00	18.80	28.00
Participants (n)	11	38	24	49

The analysis on the secondary outcomes showed no significant correlation between engagement levels and outcome behaviour data, $r = .251$, $p = .067$. The descriptive statistics for the secondary results are displayed in Table 3.

Table 3

Descriptive statistics for secondary results

	Mean	Standard Deviation	Number of Participants
Engagement	13.78	5.69	54
Stairs Climbed	16.87	7.86	54

The tertiary analysis was completed for the three types of self-efficacy and found no significant relationship for task self-efficacy, $r = .097$, $p = .357$. However significant positive correlations were found for coping self-efficacy, $r = .215$, $p = .039$, and scheduling self-efficacy, $r = .237$, $p = .023$. Table 4 shows the descriptive statistics for the tertiary outcomes.

Table 4

Descriptive statistics for tertiary results

	Mean	SD	Participants
Task SE	96.74	6.59	93
Coping SE	89.32	12.66	93
Scheduling SE	89.79	12.83	93
Stairs Climbed	15.42	7.80	93

Discussion

The general findings from this study show positive support for the inclusion of gamification in health promotion or physical activity settings. In this study we were able to find a positive effect of the gamified intervention website regardless of if the participants completed the baseline testing. In this study we were also able to retain more participants and have them stay engaged with the gamified website for a longer period of time then the control website. The is an important finding because it speaks to previous research that has been conducted that found web-based interventions can be effective so long as the participants remain engaged with the website (Davies, Corry, Van Itallie, Vandelanotte, Caperchione, Mummery, 2012; Hansen et al, 2012). A significant correlation between engagement and stair climbing was not found in this study but it is potentially due to the limited range of engagement levels as well as the way engagement was measured in this study. The background analytic software associated with the UWALK website is limited in the data that can be reported; a more sophisticated method of monitoring engagement may have lead to a significant result.

The non-significant results for the tertiary analysis of task self efficacy were likely due to a ceiling effect where the majority of scores were clustered around the top two percentages of the survey. The positive correlation for scheduling and task self efficacy show that participants who have more confidence in their ability to climb stairs in less than ideal conditions or when their schedule may not permit it did indeed climb more stairs.

The overall effect of this study also lends support to the use of stair climbing as a dependent variable or a modifiable behaviour. This is encouraging because of the availability of stairs and the relatively low amount that is needed to comply with the public health recommendations. The availability of valid and reliable commercially available physical activity monitors is another potential strength for health promotion campaigns moving forward as it allows opportunities for larger scale studies with the potential for ongoing data collection.

As this study addresses a number of areas that have previously been underrepresented in the literature it is important to note that future studies are necessary to support these results as well as to build on them. A suggestion for a follow up study is to repeat this study with a longer challenge portion to determine if the engagement levels and the behaviour levels are consistent, if there is a ceiling effect or if the begin to drop off at a certain point.

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Chapter 5: Results

5.1 Primary Outcomes

A Solomon four-group design was used in the primary outcome for this study. Table 2 is a report of the descriptive statistics for the control and intervention group at both reporting times. T-tests were completed between all necessary groups to ensure that they were not significantly different at the pre-test and the end of the study. A t-test conducted between the control and intervention groups at baseline found the groups were not significantly different, $t(35) = 0.022$, $p = .982$. T-tests were also conducted between the baseline and no baseline condition for each group and there was found to be no difference between groups for the control group and intervention group respectively, $t(16) = -0.116$, $p = .909$; $t(47) = -0.183$, $p = .856$.

Table 2.

Descriptive Statistics for Average Daily Stairs Climbed (With ITT)

	Control Group		Intervention Group	
	Pre-test	Post-test	Pre-test	Post-test
Mean	14.62	12.83	11.26	15.54
Standard Deviation	7.85	6.51	3.82	6.08
Range	21.14	25.75	16.55	21.00
Minimum	5.86	2.25	2.25	7.00
Maximum	27.00	28.00	18.80	28.00

Participants (n)	11	38	24	49

Because no differences were found between groups the statistical treatment of the Solomon Four Group Design outlined by Braver and Braver (1988) was used. The first step in the process requires a factorial ANVOA to determine if there is a treatment effect present. The results of this factorial ANOVA show that the no treatment effect is present, $F(1, 72) = .229$, $p = .633$. In addition the interaction was also not significant in this ANOVA, $F(1, 72) = 17.706$, $p = .550$; because no significant interaction was found the next step is to complete a main effect ANOVA to determine if there was a treatment effect. The results of the main effects ANOVA show a treatment effect in favour of the intervention, $F(1, 29) = 4.20$, $p = .05$. According to this statistical treatment of the Solomon Four Group Design, because a significant treatment effect was found at this stage no further analyses is required.

The primary analysis was repeated using intention to treat (ITT) principles; the method chosen for this study was last observation carry forward. The purpose of applying ITT principles is to account for the participants who dropped out of the study and protect against a type 1 error. Again a Factorial ANVOA was conducted to determine if a pre-test effect was present. The results of the ANOVA showed that no pre-test was present, $F(1, 87) = .561$, $p = .456$; the interaction effect was also non-significant, $F(1, 87) = 1.034$, $p = .312$. Because the interaction was non significant a main effect ANOVA was conducted. The main effect ANOVA showed a stronger treatment effect with the ITT principles present, $F(1, 33) = 6.339$ $p = .017$; The interaction effect was non-significant, $F(1, 33) =$

2.313, p = .138; however Figure 9. provides evidence that this may be due to a lack of power as the graph implies that an interaction is present.

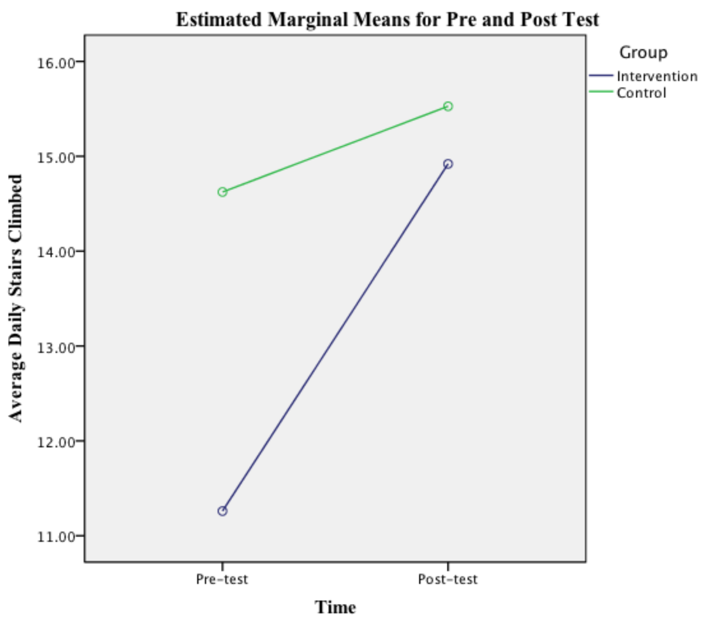

Figure 9.0 Graph of estimated marginal means.

5.2 Secondary Results

Descriptive statistics for secondary results

	Mean	Standard Deviation	Number of Participants

Engagement	13.78	5.69	54
Stairs Climbed	16.87	7.86	54

The secondary results for this study deal with the relationship between engagement and stair climbed. The results of a person product moment correlation showed a non significant relationship between the number of times participants logged their data and the number of flights that they climbed, *r* = .251, *p* = .067. Table 3. shows the descriptive results of the correlation.

Table 3.

5.3 Tertiary Results

The tertiary results deal with the outcomes of the MSES compared to the stair climbing data from the end of the study. The MSES scores were calculated based on an average of the three questions for each type of self-efficacy. The self-efficacy scores are on a scale from 0 to 100. A Person's product moment correlation was completed to determine if there was a relationship the three types of self-efficacy and average daily stairs climbed. No significant relationship was found for task self-efficacy, *r* = .097, *p* = .357. A significant positive correlation was found for coping self-efficacy, *r* = .215, *p* = .039. A significant positive correlation was also found for scheduling self-efficacy, *r* = .237, *p* = .023. The descriptive data can be found in Table 4.

Table 4.

Descriptive statistics for tertiary results

	Mean	SD	Participants

Task SE	96.74	6.59	93
Coping SE	89.32	12.66	93
Scheduling SE	89.79	12.83	93
Stairs Climbed	15.42	7.80	93

Chapter 6: Discussion

6.1 General Summary

The primary outcome of this study shows that there was a significant intervention effect. The implications of this study suggest that by adding the gamified elements to the intervention we were able to increase participant retention (there was less drop out in the intervention group than in the control group) as well as produce a significant increase in the number of stairs participants were climbing. These results support the previous research that has shown that web-based interventions can be an effective way of changing behaviour as long as participants remain engaged with the website (Hansen et. al., 2012). The statistically analysis for the primary outcomes were completed and then repeated to include intention to treat principles (Hollis, & Campbell, 1999). The ITT results were stronger than the original results. This is an important finding because it shows that the people who dropped out of the gamified group were people who were climbing more stairs earlier on. This results lends support to gamification possibly being an intervention that is successful for people who need to reach health recommendations rather than people who are already achieving them.

This study lends support to the inclusion of gamification in the health promotion field and more specifically in the area of physical activity interventions. The results of this study are in line with the previous research that has been conducted in the area of nutrition and drug compliance.

One of the main objectives of gamification is to increase engagement. In this study there was not a significant relationship found between engagement and number of stairs climbed. The results of this correlation did near significance and it is likely that there was not enough power to detect a significant relationship. Engagement in this study was defined as the number of times a participant logged their activity on the website. This is not the most sophisticated method of categorizing engagement and thus potentially limits the ability to detect a significant relationship. Another possibility for why a significant relationship was not detected is due to the limited range of engagement. The maximum number of logs possible was 20 and there was potentially a ceiling effect present because of the large number of participants clustered around the higher end of the range.

This study is one of the first studies to use stair climbing as a dependent variable. The outcomes of this study support the idea that stair climbing is a modifiable behaviour. This is an encouraging finding because of both the benefits associated with stair climbing and the availability of stairs in a most built environments.

6.2 **Future Directions**

Due to the positive outcomes associated with this study and the limited amount of research that has been completed, further research should be conducted. There are three areas that have been identified as a result of this study that in which further research is required.

One possible future direction is to control for individual gamified elements to determine if there is certain features that account for more of the behaviour change or if it is the combination of multiple elements that account for the change. There is more than one way that this type of study could be achieved; the first method would involve a website with a sophisticated background analytic software that could determine which pages are being viewed and how often. Regression equations could then be used to determine which features were accounting for the change in behaviour. A second way this result could be achieved if the website lacks the background analytic software would be to have a website where features could be enabled or disabled. In this scenario multiple groups would be needed to account for different combinations of features. Potential implications of this study would be the ability to maximize the effectiveness of the gamification by using only features that are contributing to behaviour change.

A second future direction that this research stream could take is to look at the impact of motivation with regard to how effective gamification is. Gamification is a concept that uses mostly external motivation and because if this it is potentially a less effective method for individuals who are intrinsically motivated. In this type of study participants would be categorized to different motivation classifications and the outcome data could be analyzed according to motivation to determine if there is a difference between groups. The outcomes of this study are important for tailoring health programs to individuals. If it is shown that motivation is a factor in how effective gamified programs are then would be prudent to determine the motivation type of individuals before allocating them to a specific program.

A final future direction that gamification research should take is to determine if the results of this study are sustainable over a longer period of time. As this was a pilot study and one of first studies of its kind we chose a relatively short intervention period with no post intervention follow-up. The next steps that should be taken are to replicate this study with longer challenges and see if there is sustained growth, a celling effect or if the amount of stairs climbed drops off after a while. A longer challenge will also serve to show to what extent gamification is successful at retaining participants. The follow up results will show if the changes that are experienced as a result of the study are stable over time or if the participant return back to their baseline behaviour.

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Appendix A

UNIVERSITY OF ALBERTA

Faculty of Physical Education and Recreation

E488 Van Vliet Centre
Edmonton, Alberta, Canada
T6G 2H9

WORKPLACE INFORMATION LETTER

Project: Stair Climbing Program

Researchers:
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P4-26 Van Vliet Centre
University of Alberta, Edmonton
Telephone: (780) 492-7424
Fax: (780) 492-1008

Dr. Kerry Mummery
Dr. Cally Jennings

Dear ___________,

Your workplace is being invited to participate in the pilot testing of a workplace physical activity challenge program. As a part of this program we have designed a challenge that will target stair climbing. Your work place will be assigned to either the full program or a basic version (for four weeks with access to the full program at the end of the study). In addition we will loan employees participating in program a Fitbit One physical activity monitor to wear for six weeks (a two week baseline assessment and then the four week duration of the program). Employees will be required to complete a questionnaire at three different times (the beginning of the six weeks, four weeks in, and then again at the end of the six weeks). Employees will be asked to engage with the program website in order to log and monitor their progress at least once each day. This interaction with the website should not cause any adverse effect on working time.

The premise of this challenge program is to encourage individuals to climb more stairs throughout the day in lieu of taking the elevator. There is a known relationship between climbing stairs and a lowered risk of many diseases.

There are no known risks associated with your participation and involvement is entirely voluntary. Therefore, you are free to withdraw from the research at any time without penalty. If you withdraw from the study, your information will be removed upon your request.

If you have any questions about this study, you can contact Shayna Fairbairn at (780) 492-7424 or sfairbai@ualberta.ca. Alternatively, if you wish to speak with someone who is not involved with this study, please call the Research Ethics Office at (780) 492-2615.

Thank you for your involvement in our research project!

Appendix B

UNIVERSITY OF ALBERTA

Faculty of Physical Education and Recreation

E488 Van Vliet Centre
Edmonton, Alberta, Canada T6G 2H9

CONSENT FORM

I _______________________________________ (*please print full name*), agree to participate in the Effectiveness of a Stair Climbing Program Using a Monitoring Device study.

I have read the information sheet and I understand that:

- My personal information will not be linked to the data collected.
- I understand that the project involves climbing multiple flights of stairs. I do not have any conditions that I know of that would prevent me from completing task or would cause me to be at an elevated risk of harm by participating in this study.
- I understand that I can withdraw from the study or withdraw my data from the study at any point until the end of the study.
- The data collected will be stored in a secure location indefinitely.

Participant signature: ____________________________ Date: ____________________________

Please contact Shayna Fairbairn (sfairbai@ualberta.ca or (780) 492-7424) if you have any questions.
The plan for this assessment has been approved by the Research Ethics Board at the University of Alberta. For questions regarding participant rights and ethical conduct of research, contact the Research Ethics Office at (780) 492-2615.

I believe that the person signing this form understands what is involved in the study and voluntarily agrees to participate.

____________________________________ ____________________________

Signature of Investigator or Designee Date

Appendix C

Physical Activity Readiness Questionnaire - PAR-Q (revised 2002)

PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO		
☐	☐	1.	**Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?**
☐	☐	2.	**Do you feel pain in your chest when you do physical activity?**
☐	☐	3.	**In the past month, have you had chest pain when you were not doing physical activity?**
☐	☐	4.	**Do you lose your balance because of dizziness or do you ever lose consciousness?**
☐	☐	5.	**Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?**
☐	☐	6.	**Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?**
☐	☐	7.	**Do you know of any other reason why you should not do physical activity?**

If you answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
- if you are or may be pregnant – talk to your doctor before you start becoming more active.

PLEASE NOTE: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME ______________________

SIGNATURE ______________________ DATE ______________________

SIGNATURE OF PARENT ______________________ WITNESS ______________________
or GUARDIAN (for participants under the age of majority)

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

Appendix D

Please indicate HOW CONFIDENT YOU ARE THAT YOU CAN PERFORM each of the exercise related tasks below

0% 100 20% 30% 40% 50% 60% 70% 80% 90% 100%

a. How confident are you that you can climb stairs __________%

b. How confident are you that you can follow directions to climb stairs__________%

c. How confident are you that you can perform all of the movements required for stair climbing __________%

d. How confident are you that you can climb stairs when they cause some discomfort __________%

e. How confident are you that you can climb stairs when you lack energy__________%

f. How confident are you that you can include stair climbing in your daily routine __________%

g. How confident are you that you can complete the recommended number of flights of stairs each week __________%

h. How confident are you that you can climb stairs when you don't feel like it___________%

51i. How confident are you that you can arrange your schedule to include regular stair-climbing ___________%