Effects of a brief web-based intervention on motivation, attitude, and physical activity in adults

by

Rebecca L. Gasper

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Approved by:

Major Professor
Dr. Emily Mailey

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Abstract

BACKGROUND: The high prevalence of physical inactivity in America is associated with the development of multiple chronic health conditions and a growing burden on the healthcare system, causing a public health crisis. An ineffective communication strategy regarding how and why people can be physically active may be partially to blame for this crisis. Messages coming from various sources, including physicians, the federal government, professional organizations, and the media, promote physical activity in a way that does not support the three key psychological needs of autonomy, competence, and relatedness described by the Self-Determination Theory (SDT). To address these deficiencies, the present study sought to compare the impact of brief online modules utilizing SDT-supportive strategies to promote autonomy and competence to information-based modules on participant levels of autonomous motivation, attitude, perceived behavioral control (PBC), and physical activity behavior.

METHOD: Four online modules were developed for inactive adults ages 22-45 and were delivered over the course of four weeks via Qualtrics. Participants were randomized into the intervention (n=66) or control (n=66) condition, with the intervention modules including more autonomy-supportive content and recommendations to re-frame physical activity as a more feasible activity that one can benefit from immediately. Both groups completed modules relating to similar topics, including the benefits of physical activity, physical activity recommendations, barriers, and external influences. Repeated measures ANOVAs were utilized to examine changes in autonomous motivation, attitude, PBC, and physical activity behavior from pre-post intervention between groups.

RESULTS: Participants from both groups reported an increase in autonomous motivation [$F(1,66)=16.207$, $p=<.001$], overall attitude towards physical activity [$F(1,65)=4.726$, $p=.033$],

and PBC [$F(1,66)=9.191$, $p=.002$]. There was no significant change in physical activity behavior [$F(1,68)=.122$, $p=.728$] during the four-week pre-post assessment, and there were no significant differences detected between groups.

CONCLUSION: A four-week online intervention positively impacted autonomous motivation, attitude, and perceived behavioral control regarding individual physical activity behavior. These findings suggest that implementing recommendations to re-frame physical activity through brief interactive and information-based modules could be an effective strategy to increase the psychological precursors of physical activity behavior. However, additional strategies may be necessary to translate psychological changes to physical activity behavior. Future interventions could benefit from identifying ways to increase the reach of the program and incorporating a longer follow-up to assess if the psychological changes are translated to behavior.

Keywords: motivation, physical activity, Self-Determination Theory, web-based intervention

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Chapter 1 - Literature Review

Physical Inactivity: A Public Health Crisis

The United States Department of Health and Human Services recommends that Americans achieve at least 150 minutes of moderate or 75 minutes of vigorous aerobic activity per week in combination with two or more days of strength training for general health (US Department of Health and Human Services, 2008).To attain additional health benefits, including better weight management and reduced risk of cancer, adults should achieve double the recommended amount of aerobic activity (Kushi, et al., 2012; US Department of Health and Human Services, 2008). However, approximately 80% of Americans do not even achieve the minimum weekly recommended amount of both aerobic and muscle-strengthening activity and 24.2% report no leisure time physical activity whatsoever (Centers for Disease Control and Prevention, 2013; Centers for Disease Control, 2017).

Physical inactivity is a major public health concern because of the multiple chronic conditions associated with it, especially obesity, which could be largely prevented through a more active lifestyle (Warburton, Whitney, & Bredin, 2006; Kruk, 2007). Some of these conditions include cancer (colon & breast), cardiovascular disease, stroke, hypertension, type II diabetes, and osteoporosis (Warburton, Whitney, & Bredin, 2006). Obesity is another chronic condition associated with physical inactivity, with approximately 1 in 3 Americans now classified as overweight (with a BMI >25) and 29.6% considered obese (BMI $\geq$30) (Centers for Disease Control and Prevention, 2017). Obesity alone is a risk factor for many of the same chronic conditions listed above and is one of the five components of Metabolic Syndrome (Huang, 2009).

To further the problem of physical inactivity, recent research suggests that even individuals who are at a 'healthy' weight can still suffer from the negative health consequences of being inactive, including an increased risk of heart attack (Barry, et al., 2014). A meta-analysis found that the risk of developing negative health outcomes has a stronger association with cardiorespiratory fitness than an individual's Body Mass Index (BMI, an indicator of obesity). This finding suggests that a lack of physical activity puts individuals at a greater risk for cardiac events than active individuals regardless of their BMI classification, (Barry, et al., 2014). This increased risk further emphasizes the point that engaging in physical activity is an essential part of health maintenance across the lifespan.

In addition to the negative impact on individual health, public health overall is being significantly impacted by the rise in chronic conditions associated with physical inactivity through the healthcare costs associated with managing these diseases. The United States currently spends about $186 billion annually on costs related to physical inactivity (PHIT America, 2018). Of this, about $134 billion is considered direct costs (PHIT America, 2018). The total costs related to physical inactivity accounts for approximately 11.1% of aggregate health care spending (Carlson, Fulton, Pratt, Yang, & Adams, 2015). This information paints a bleak picture of both present and future health of Americans; however, the good news is that most of these chronic diseases, and corresponding health care expenses, can be largely prevented by a physically active lifestyle. The fact that physical activity can positively impact one's health was first identified in a study comparing British double-decker bus drivers who sat for the majority of the day to conductors who were more active during the day, which found that the conductors had lower rates of disease than the sedentary bus drivers (Morris, Heady, Raffle, Roberts, & Parks, 1953). Research since this time has found even more benefits of regular

physical activity, including: stronger muscles, improved immune system functioning, reduced feelings of depression and anxiety, better sleep, improved cognitive function, improved body composition, better cholesterol levels, and decreased risk of developing certain cancers, including colon and breast (Kruk, 2007; Warburton, Whitney, & Bredin, 2006).

Yet despite these well-documented benefits of engaging in regular physical activity the majority of Americans continue to not achieve the recommended amounts of physical activity (Centers for Disease Control and Prevention, 2013) This is part of the reason why the health status of Americans is projected to worsen over the next few decades, with some estimates predicting that 50% of the US population will be obese by 2030 (Finkelstein, et al., 2012). Compounding this problem is the fact that a large part of the American population is aging, and the percentage of people who are insufficiently active, including those whose total activity is below the recommended amounts, or people who are completely inactive increases with age (Carlson, Fulton, Pratt, Yang, & Adams, 2015). This negative association with age will result in even worse health outcomes and increased burden on the healthcare system if the baseline level of physical activity is low across the population in their younger, more 'active' years (Wee et. al, 2005). Therefore, it is important that public health interventions target people while they are still in the earlier stages of life to foster the development of an active lifestyle in a way that can be sustained long-term.

Why Physical Inactivity is Still a Problem

One explanation for the continued, and even growing, problem of physical inactivity is the relationship between knowledge and behavior. Studies have shown that a certain degree of knowledge is essential to engaging in a behavior (Williamson, 2016); however, there is also evidence that knowledge by itself is not sufficient to promote engagement in a given health

behavior. For example, a study of recent high school graduates ages 16-19 found that the students had a good understanding of health behavior, yet still did not engage in what was considered a 'healthy' lifestyle (Koehn, Gillison, Standage, & Bailey, 2016). Furthermore, interventions that incorporate additional strategies beyond health education are typically more effective at producing the desired psychological and behavioral changes (Silva, et al., 2010; Rothert, et al., 2006). These studies showing that knowledge does not always translate to behavior support the idea that there are other factors mediating the relationship between knowledge and behavior.

Investigations into the factors impacting the knowledge-behavior gap have identified various barriers in translating knowledge to behavior, including: lack of time, lack of equipment/facilities, fear of injury, feeling tired or lacking energy, not knowing what to do, or feeling self-conscious (Trost, Owen, Bauman, Sallis, & Brown, 2002; Williams, Anderson, & Winett, 2005). Some of these barriers exist at the individual level, while others are related to social or environmental conditions. The correlates of physical activity behavior were synthesized in a review of reviews conducted by Choi et. al. (2017), and results indicated significant associations between physical activity and factors at both the individual and environmental level. Notably there were 53 individual factors considered to be 'definitely associated' with physical activity, including demographic factors like age and gender, as well as psychological factors including self-efficacy, attitude, and outcome expectations (Choi, Lee, Lee, Kang, & Choi, 2017). There were also 10 'definitely associated' environmental factors, which included safety, accessibility, and aesthetics (Choi, Lee, Lee, Kang, & Choi, 2017). These findings support the complexity of physical activity behavior such that it can be influenced by factors at different levels over which the individual has varying degrees of control. Due to the greater number of

correlates at the individual level, the focus of the remainder of this literature review is on the individual and how environmental level influences are processed at this level.

Individual-level factors can be broken up into two categories: demographic characteristics and psychological factors. Many of the demographic traits such as age, gender, education, and income can be difficult (or impossible) to change, making the psychological factors the ideal target for behavior change. These psychological factors, including self-efficacy, motivation, attitude, and perceived behavioral control, tend to differ between physically inactive and active individuals. However, one key psychological factor that has been frequently studied to explain differences between these populations is their source of motivation. This relationship between motivation and behavior is described in more detail by Deci and Ryan's Self-Determination Theory (SDT).

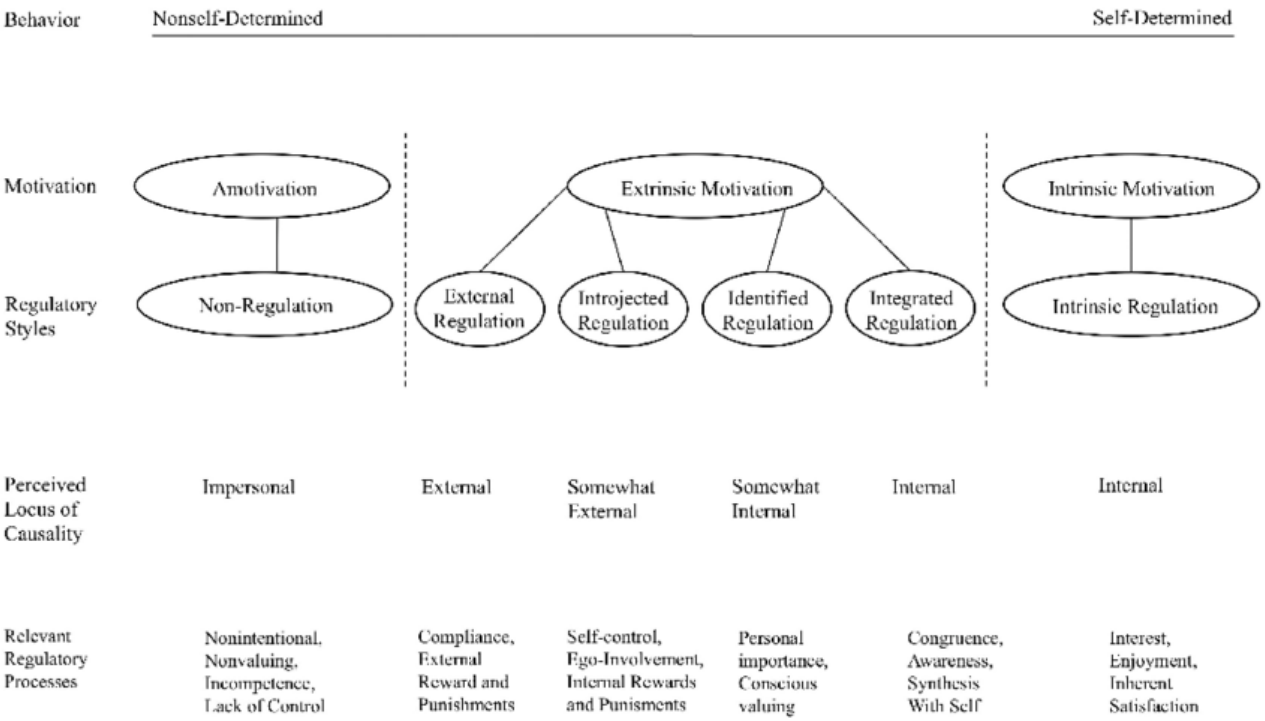
Self-Determination Theory

Self-Determination Theory (SDT) attempts to explain human behavior through an intuitive, subconscious pursuit to satisfy the three core psychological needs for autonomy, competence, and relatedness. (Deci & Ryan, 2000). *Autonomy* can be defined as having a sense of control over one's behavior and that one's actions are self-endorsed (Ryan & Deci, 2008). A sense of autonomy indicates that individuals feel their actions are a result of their personal choices and they are not being coerced or controlled by an outside influence. *Competence* can be defined as feelings of confidence and being effective in one's actions or abilities (Ryan & Deci, 2008). *Relatedness* can be defined as a feeling of connectedness with others, or a sense of belonging (Ryan & Deci, 2008). The SDT proposes that these three needs are an essential part of well-being and need to be satisfied for people to function at their optimal level. Deci and Ryan argue that ultimately people will "pursue goals, domains, and relationships that support their need

satisfaction", and that if a behavior goes against one of the three needs it is unlikely to be pursued repeatedly (Deci & Ryan, 2000, p. 230).

SDT has also been expanded to include a spectrum of motivation explaining different reasons why an individual may engage in a behavior, which can be seen in Figure 1-1. Each level of motivation on the spectrum is classified as either intrinsic or extrinsic. Intrinsic motivation involves doing something because the activity is inherently enjoyable or satisfying with no incentive necessary, whereas extrinsic motivation involves doing something to either attain or avoid a specific outcome (Ryan, Williams, Patrick, & Deci, 2009). Within these general categories, the motivation spectrum progresses through increasingly self-determined sources of motivation. The first level is *amotivation,* which is considered the complete absence of motivation. The next four levels are types of extrinsic motivation, with the least self-determined being *external regulation*. This is when an individual engages in a behavior to accomplish an external outcome, which could be to either earn a reward or to avoid a punishment from an external source (Ryan & Deci, 2000). The next level is *introjected regulation,* where the individual engages in a behavior due to a sense of internal obligation related to self-esteem. *Introjected* behaviors are often done to avoid feelings of guilt or enhance one's sense of self (Ryan & Deci, 2000). *Identified regulation* is when the behavior is of personal importance to an individual, while *integrated regulation* occurs when the behavior is fully incorporated into one's sense of self (Ryan & Deci, 2000). Each of these forms of motivation is considered extrinsic, although higher levels are considered to be more self-determined within personal control. Behaviors regulated by more external influences are considered the least sustainable and those that are more internalized are associated with maintaining the behavior over time (Deci & Ryan, 2000).

Figure 1-1: SDT Spectrum of Motivation (Ryan & Deci, 2000)



This spectrum of motivation can be further broken down into *controlled* vs. *autonomous* forms of motivation. Controlled motivation is the idea of engaging in a behavior because one feels like they 'should' or 'have' to do it, whereas autonomous behaviors occur because an individual makes the choice to do it (i.e. they 'want' to) (Teixeira, Carraca, Markland, Silva, & Ryan, 2012). *Extrinsic* and *introjected* levels of motivation are typically categorized as controlling because they involve engaging in an activity to earn a reward or avoid a punishment, which can come from either an external or internal source (Ryan & Deci, 2000). As one moves up the motivation spectrum, the behaviors become more internalized and a transition occurs toward autonomous regulation. Identified and integrated regulations are generally regarded as autonomous because actions undertaken from this motivation are more self-endorsed (Ryan & Deci, 2000).

Due to the detailed breakdown of motivation outlined in SDT it has been widely utilized as a framework to understand the complexity of physical activity behavior. A systematic review by Teixeira, et. al (2012) combined results from 66 previous studies. Considering the three core needs, the authors found that greater levels of perceived competence and autonomous regulation are positively associated with exercise behavior, while relatedness tended to have a non-significant association with physical activity behavior (Teixeira, Carraca, Markland, Silva, & Ryan, 2012). These findings suggest that although all three needs are essential for optimal human functioning and can influence behavior decisions, particular attention should be paid to supporting competence and autonomy in relation to physical activity. The review also found that more self-determined sources of motivation were positively associated with maintained exercise behavior. The strongest evidence exists for identified and intrinsic motivation, and positive trends were also found among the few studies that have specifically investigated integrated regulation (Teixeira, Carraca, Markland, Silva, & Ryan, 2012).The stronger evidence for internal sources of motivation supports the idea that exercising for reasons of personal value to individuals and integrating physical activity into a personal sense of self is associated with sustaining a physically active lifestyle. However, despite the evidence supporting the idea that internal sources of motivation are necessary for long-term sustainability of exercise behavior, the way in which physical activity is often promoted to the public emphasizes external motives such as improved appearance or disease prevention.

Current Physical Activity Messages: The Problems

When promoting an activity or behavior, especially an activity that someone may not be personally familiar with, the framing of the activity plays a key role in determining whether someone will try it. Messages about physical activity come from a variety of sources, including

fitness professionals, physicians, social media, blogs, commercial companies, and public health campaigns as well as scientific organizations such as the American College of Sports Medicine (ACSM) and the Centers for Disease Control and Prevention (CDC) (Berry & Latimer-Cheung, 2013; Ekkekakis, 2013). Americans are constantly bombarded with different reasons why they should be more active, including to improve their health, decrease their risk of diseases, and enhance their physical appearance. Exercise is now even being equated to medicine to be prescribed by doctors, as represented by ACSM's *Exercise is Medicine* movement (American College of Sports Medicine, 2010). Although each of the previously listed reasons to be active are valid, they have been found to be an ineffective at supporting a physically active lifestyle when they are the only source of motivation. Evaluating the current messages utilized to promote physical activity leads to the identification of three main problems.

Problem #1: Conflicting Messages

One problem with the current physical activity promotion messages is that a multitude of sources promote physical activity, and each of them has a different reason for encouraging people to be active. Some sources, like fitness facilities, are promoting physical activity as a mechanism to sell gym memberships whereas doctors often promote physical activity as a means to prevent disease. Professional public health organizations like the CDC, ACSM, and the federal government also promote physical activity to enhance health. However, the issue is that the diverging motives of the organizations promoting physical activity has resulted in contradictory messages being sent to the public, leaving people with an awareness that they should be active but no clear or consistent message as to why. As Ekkekakis (2013) points out, Americans have experienced multiple versions of physical activity guidelines sponsored by many different, reputable organizations in the last 20-30 years. The frequent updating of these recommendations

to reflect advances in physiology research has created confusion among both the general public and physicians (Ekkekakis, 2013). There also continues to be confusion as to what 'counts' as physical activity, which has resulted in an 'all or nothing' perspective that if one doesn't move for at least 10 minutes or do structured exercise that their general movement throughout the day is unimportant (Ekkekakis, 2013). This idea can make physical activity feel like a challenging task, which undermines the fundamental need for competence. If individuals do not consider themselves capable to meet the guidelines as prescribed they are less likely to attempt to engage in physical activity on a regular basis, or possibly even be active at all.

Problem #2: Promotion of External Motivators

The next problem with current physical activity messages is that they primarily promote external motivators. These motivators are rewards or punishments that the individual will either earn or avoid by engaging in the behavior, including enhanced appearance and even improved health (Deci & Ryan, 2000). For example, the covers of *Men's Health* and *Women's Health* magazines primarily promote the 'ideal' body types of thin females and muscular males along with objectifying phrases (Bazzini, Pepper, Swofford, & Cochran, 2015). Additionally, the predominant motive for engaging in physical activity reported by adults of all ages is *toned and fit* (Gavin, Keough, Abravanel, Moudrakovski, & Mcbrearty, 2014). It is possible that the frequent promotion of appearance enhancement motives has conditioned people to identify this external motivator as the reason they should engage in physical activity. Although these external motivators may help people initiate a behavior, they have been found to be ineffective at helping people sustain the behavior over time (Teixeira, Carraca, Markland, Silva, & Ryan, 2012). This inability to sustain activity over time is because working for an external goal (i.e. improved appearance) leads to exercise being viewed as a necessary action to achieve the result. Therefore,

when someone meets their goal there is no longer a need to continue exercising. This problem has been found in weight loss studies, where individuals who engaged in exercise to lose weight tend to stop exercising after they reach their goal and are unable to maintain their weight loss (Wing & Hill, 2001).

Besides not maintaining a behavior after a goal is met, relying on extrinsic motives alone could also prevent individuals from ever meeting their goal. Motivation is the foundation of behavior, but self-regulation is essential to sticking with behaviors and reaching goals. For example, to achieve the goal of avoiding certain chronic diseases as someone ages, they need to engage in regular physical activity across their lifetime. However, if they are only being active because they feel like it is the right thing to do and there is no enjoyment in being active then they are likely experiencing controlled motivation. This sense of control or obligation to be active can undermine the fundamental need for autonomy, and as described by the SDT, a lack of support for autonomy can result in behavior cessation (Deci & Ryan, 2000). However, it is also possible develop internal motives coexisting with external motives, or to transition from extrinsic to intrinsic motives over time. Even in the presence of external motives, if an individual has internal reasons for being active there is a greater likelihood of sustaining physical activity over time.

Problem #3: The Role of Personal Affect is not Maximized

Another important factor in the sustainability of exercise behavior is the role of personal affect, or individual feelings and emotions. Affective outcomes, such as feelings of increased energy, reduced stress, and enjoyment, can be experienced during and/or immediately after exercising. Human nature drives people to engage in things that feel good or make them happy and to avoid things that produce negative feelings like pain or unhappiness. If positive feelings are

experienced during or after physical activity, people are more likely to repeat that behavior. A study asking participants to complete a feelings scale survey before, during, and after walking on a treadmill for 10 minutes found that those who reported a more positive affect during exercise were more active over the course of the one-year follow-up (Williams, Dunsiger, Jennings, & Marcus, 2012). Additionally, a series of studies by Woolley & Fishbach (2016) investigated the relationship between proximal and distal rewards on behavior adherence. One study found that participants were more likely to adhere to their New Year's resolutions when they reported positive experiences or enjoyment after engaging in their goal behavior (Woolley & Fishbach, 2016). Another study in this series involved undergraduate students exercising at a campus fitness facility found that those intending to complete aerobic exercises at the gym exercised more during the week when they focused on immediate rewards (i.e. fun/enjoyment) compared to students who valued a delayed reward (i.e. staying in shape) (Woolley & Fishbach, 2016). Also, 'priming' people to focus on the immediate benefits of physical activity can produce a more internalized source of motivation that is positively associated with long-term behavior maintenance (Evans, Cooke, Murray, & Wilson, 2014).

Pleasure and enjoyment are two key affective outcomes that are largely missing from current physical activity promotion messages. Ekkekakis (2013) stated that "Pleasure experienced during bouts of physical activity predicts subsequent physical activity participation" (Ekkekakis, 2013, p. 1429). Individuals who engage in physical activity on a regular basis typically cite pleasure-related factors like enjoyment or energy as reasons for adhering to physical activity (Ekkekakis, 2013). In contrast, those who do not adhere to a physical activity routine cite unpleasant factors like exhaustion or pain as the reason for dropping out (Ekkekakis, 2013). These unpleasant experiences are often associated with higher-intensity physical activity

that individuals may perceive as the required structured exercise intensity that one must complete for their physical activity to 'count' (Ekkekakis, 2013; Segar, Taber, Patrick, Thai, & Oh, 2017). Individuals may feel they 'should' exercise at this higher intensity, which also undermines their sense of autonomy and adherence to a physical activity routine.

Approaches to Changing Physical Activity Behavior

The previous sections have explained how messages surrounding physical activity can negatively impact the key psychological factors associated with sustainable behavior change and ultimately have been ineffective at curbing the physical inactivity crisis. This disconnect between research on the relationships between the three psychological needs and long-term physical activity behavior and the messages communicated to the public highlights the importance of maintaining a theoretical and research base for physical activity promotion messaging and intervention efforts. Due to the strong and repeated associations found between SDT and physical activity, SDT has served as a framework for many physical activity interventions (Ryan, Williams, Patrick, & Deci, 2009; Teixeira, Carraca, Markland, Silva, & Ryan, 2012). Intervention approaches have varied, each with differing levels of resources, time, and extent to which the theory is incorporated into the intervention. A study conducted among obese individuals compared those receiving general health education with a SDT-based intervention that created an autonomy-supportive environment. After the one-year study, participants who received the SDT-based intervention had greater levels of physical activity, autonomous self-regulation, competence, locus of causality, and enjoyment of exercise and maintained these changes through the two-year follow-up assessment (Silva, et al., 2011). Another intervention entitled "Fitting in Fitness for Life! (FIF)" involved the combination of theory-based strategies and creating a sense of empowerment over personal goals to increase physical activity in middle-age women (Segar,

Jayaratne, Hanlon, & Richardson, 2002). The intervention involved multiple small-group meetings over the six-week study period plus additional activities to be completed individually, and participants experienced significant increases in self-care prioritization and pleasure-based approaches to physical activity from pre-post intervention (Segar et. al, 2002). Importantly, this study also found significant increases in physical activity from baseline to a long-term follow-up, suggesting that the intervention was successful at prompting a long-term behavior change (Segar et. al., 2002).

While both of these SDT-based interventions produced long-term changes in physical activity, they also required a lot of resources and time to implement. Although neither of these studies included a direct cost-analysis, it is possible that the expense of designing and implementing these interventions that reached 221 and 50 participants respectively could have outweighed the long-term impact on participant physical activity and overall public health outcomes. The cost-effectiveness of interventions and feasibility of delivering them on a large scale are factors that must be considered when facing a physical inactivity crisis of the present scale.

To reach a larger audience, many interventions are now being delivered online. A review conducted by Joseph et. al (2014) found 72 internet-based physical activity interventions that were delivered from 2001-2012. The review found that previous studies comparing digital and in-person or print-based interventions with similar content have demonstrated both methods of delivery to be equally effective at promoting physical activity (Joseph, Durant, Benitez, & Pekmezi, 2014). Another key finding of this review was that short-term interventions (<6 months) are just as effective at increasing physical activity as longer interventions (>6 months) (Joseph, Durant, Benitez, & Pekmezi, 2014). Furthermore, although the review found that Social

Cognitive Theory and the Transtheoretical model were the most commonly utilized theories, there was no significant difference between interventions based in theory and those that were non-theoretically based (Joseph, Durant, Benitez, & Pekmezi, 2014). However, a systematic review and meta-analysis conducted by Webb et. al (2010) found that online interventions that utilized theory had a greater effect on physical activity behavior change than those without a theoretical basis, and an even greater effect was seen with the incorporation of additional behavior change strategies and opportunities for participant interaction with the intervention (Webb, Joseph, Yardley, & Michie, 2010). Based on the results of these two reviews, it can be speculated that theory should be utilized as a guiding framework while developing an intervention, but the rigidity with which theory-based strategies are implemented may not provide an additional impact on the target outcomes.

Future Directions for Sustainable Physical Activity Promotion

Many physical activity interventions in addition to those described have been implemented in an attempt to increase physical activity. While some may have had success within their study population at establishing both short and long-term changes, a gap remains in determining the most effective and feasible way to address the problem on a larger scale.

A first step in addressing the inactivity problem is changing the way in which physical activity is presented to the population. Ekkekakis (2013) argues that message confusion is one of the primary issues with how physical activity has been traditionally promoted, suggesting that groups who advocate for physical activity should work together to develop a consistent message about why people should be physically active. The immediate, positive affective benefits of physical activity, including enhanced vitality and overall mood, should be the focus of future physical activity promotion communication (Segar, Guerin, Phillips, & Fortier, 2016). This

strategy can be effective because humans tend to make decisions based on emotion rather than logical processing (Pham, 2007). Physical activity has been historically promoted to the logical decision-making process by touting the long-term health benefits of being active; however, these goals are also in the distant future, making it possible for the emotional decision-making processes of the present to triumph over the logical processes of making behavior decisions for future benefit.

Clarification also needs to be provided on what strategies individuals can use to accomplish the recommended minutes and amount of weekly aerobic and muscle strengthening activity. When discussing these activities, it is important to present them in a way that will support the three core psychological needs as defined by the SDT. Emphasizing that physical activity can be any activity that the individual enjoys, can be completed in shorter bouts, and does not always have to be at a vigorous intensity can increase perceived competence and autonomy. This is because when individuals consider physical activity as something they can do, as well as something they enjoy doing, their psychological needs are met and they are more likely to adhere to a physical activity routine (Teixeira, Carraca, Markland, Silva, & Ryan, 2012; Deci & Ryan, 2000). Some physical activity interventions have already begun re-framing physical activity to focus on the immediate, affective benefits and re-defining it to highlight activities that people enjoy. However, one drawback of many previous interventions is that their reach is often limited by the sizeable amount of resources required.

Purpose of the present study

The present study, known as the Daily Activity Motivation Study (DAMS), aimed to alter participant perceptions of physical activity to focus on the immediate benefits of being active, and to deliver the content in an online format that required fewer resources than previous

interventions. The review by Joseph et. al. (2014) found that short-term online interventions were as effective at increasing physical activity as longer interventions, but the required minimum intervention dose to promote a sustainable behavior change remains unknown. The extent to which autonomy-supportive interventions can be effectively delivered online utilizing SDT warrants additional investigation as previous web-based studies have rarely utilized SDT. Delivering the intervention entirely online also enhances the potential for implementation on a larger-scale because the online intervention requires fewer resources than interventions utilizing mixed digital and in-person strategies. A unique component of DAMS was the incorporation of reflection questions before and after completing the interactive modules. Participants typed their initial response to a question related to the weekly module topic and were asked to reflect on how their answer may have changed after completing the module. This reflection also prompted participants to identify how they can incorporate the content into their lives, making it an implementable action plan instead of an abstract concept. Therefore, the purpose of DAMS was to examine the impact of brief online modules that re-frame participant perceptions of physical activity on motivation, attitude, perceived behavior control, intentions, and physical activity behavior. It was hypothesized that participants completing the more interactive SDT-based intervention modules would experience greater increases in all psychological variables as well as greater increases in physical activity behavior compared to participants completing the information-based modules.

Chapter 2 - Introduction

The United States is currently facing a physical inactivity crisis, with approximately 80% of Americans not achieving the minimum recommended amount of both aerobic and muscle-strengthening activity per week (Centers for Disease Control, 2017). Physical inactivity has been associated with the development of multiple chronic diseases, including cancer (colon & breast), cardiovascular disease, stroke, hypertension, type 2 diabetes, and osteoporosis (Warburton, Whitney, & Bredin, 2006). The growing presence of chronic diseases has also created a health care crisis with escalating economic costs of providing health care and long-term management of these diseases (Hamilton, Healy, Dunstan, Zderic, & Owen, 2009; Wilmot, et al., 2012; Carlson, Fulton, Pratt, Yang, & Adams, 2015). Some studies estimate that about 8-10% of total health care expenditures, which equates to ~$60-$100 billion, can be attributed to insufficient physical activity (Carlson, Fulton, Pratt, Yang, & Adams, 2015). However, the good news is that increasing physical activity can help significantly reduce these health care costs. People who engage in activity for just 30 minutes 3 days per week have lower secondary and tertiary health care expenses, and being regularly active is associated with lower overall annual health care expenses per individual (Kang & Xiang, 2017; Pratt, Macera, & Want, 2015).

The benefits of being physically active have been known for years, yet the majority of U.S. adults are still insufficiently active. Many factors, particularly the absence of motivation, influence this knowledge-behavior gap. Previous studies have found that knowledge is often not enough to prompt a behavior change (Sherwood & Jeffery, 2000). For example, a study involving recent high school graduates ages 16-19 found that although the students had a good understanding of health behavior they still did not engage in what was considered a ‘healthy’ lifestyle (Koehn, Gillison, Standage, & Bailey, 2016). Furthermore, studies comparing an

information-based control to an intervention incorporating theory-based, or personally-tailored, content report greater success in translating knowledge to sustained behavior (Silva, et al., 2010; Rothert, et al., 2006). The Self-Determination Theory (SDT) is a behavior change theory commonly utilized to understand motivation as a means to explain and predict behavior. It identifies three core human psychological needs of autonomy, competence, and relatedness (Deci & Ryan, 2000; Ryan & Deci, 2008). The theory proposes that individuals operate on a subconscious level to meet these three needs, and if engaging in a certain behavior goes against one of these needs, the behavior is not sustainable. Not only have many interventions based in SDT been effective at increasing physical activity behavior, those focused specifically on increasing autonomy have been found to prompt a long-term behavior change (Deci & Ryan, 2000; Ryan, Williams, Patrick, & Deci, 2009; Silva, et al., 2010; Teixeira, Carraca, Markland, Silva, & Ryan, 2012). The sustainability of a physical activity behavior change is more important than simply triggering a short-term increase in activity in order to adequately address the physical inactivity crisis.

Despite the strong association between SDT need satisfaction and sustained behavior change, this information has not been appropriately translated outside of research interventions to the general population. These messages have inadequately supported some of the key psychological factors associated with sustained physical activity behavior in two important ways. The first issue is that multiple sources regularly distribute messages about how much and what type of physical activity people should do. This influx of often conflicting information has resulted in an unclear message regarding how much activity individuals should accomplish, which creates confusion and ultimately leads to an inability to sustain physical activity in the long-term (Ekkekakis, 2013; Berry & Latimer-Cheung, 2013). The duration and intensity

recommendations presented in the Physical Activity Guidelines have also contributed to an 'all or nothing' perspective where if one does not move for at least 10 minutes they perceive that their activity does not 'count' towards the weekly recommendations. This notion serves to undermine the fundamental need for competence by promoting an amount of activity that an individual does not consider feasible and undermines the need for autonomy by creating feelings that a certain amount needs to be done regardless of personal preference for the type or duration of activity (Deci & Ryan, 2000). A lack of support for both autonomy and competence makes it extremely difficult for individuals to maintain a behavior change long-term.

The second problem is the prominent messages emphasizing enhanced appearance or disease prevention as reasons why an individual should participate in physical activity. A focus on these reasons creates the idea that one 'should' be physically active, which is considered a more controlled source of motivation and has been associated with lower rates of physical activity over time (Segar, Eccles, & Richardson, 2008; Deci & Ryan, 2000). More internal and autonomous motives for engaging in physical activity are associated with adhering to a more active lifestyle, particularly when being active is perceived as enjoyable or associated with outcomes that are highly valued (Teixeira, Carraca, Markland, Silva, & Ryan, 2012). Valuable outcomes can include those that have a positive impact on one's daily quality of life, which typically can be experienced within a short time frame after engaging in physical activity (Segar, Taber, Patrick, Thai, & Oh, 2017). It is a part of human nature to rely more on emotions than logic when making decisions, which contributes to the tendency to choose options that will provide immediate gratification (Pham, 2007; Chang & Pham, 2013). This inclination suggests that it may be better to focus on the human desire for immediate gratification by communicating

the immediate, affective benefits of being physically active, which can also help foster the connection between physical activity and personally valued outcomes.

This idea of re-framing perceptions of physical activity as something that can provide an immediate benefit has been found to increase psychological perceptions of physical activity that support a sustained behavior change. Enjoyment, stress reduction, vitality, and enhanced daily quality of life are just a few short-term affective outcomes that have been associated with long-term physical activity behavior (Ekkekakis, 2013; Segar, Eccles, & Richardson, 2011; Segar, Guerin, Phillips, & Fortier, 2016). Promotion of these affective outcomes that facilitate an autonomous choice to pursue the behavior, along with re-defining physical activity to include more daily activities to support perceived competence, can foster the internalization of the behavior and subsequent increased likelihood of continuing to engage in the behavior (Segar, Guerin, Phillips, & Fortier, 2016). Interventions re-framing physical activity to promote these short-term affective outcomes have had some success at creating long-term sustained change. For example, a 2002 study by Segar et. al utilized small group meetings and activities to enhance participant awareness that all activity 'counts' and promoted physical activity as an enjoyable self-care activity. Increases in physical activity were seen following the six-week intervention and were maintained through a follow-up period, which ranged from 5-13 months depending on when participants completed the intervention. (Segar, Jayaratne, Hanlon, & Richardson, 2002). However, the extent to which these positive changes can be achieved more broadly may be limited by the need for in-person meetings and researcher availability to deliver the intervention strategies.

Many physical activity interventions are now being delivered online to increase their reach and take advantage of the increasing presence of technology in society. A meta-analysis of 72 internet-based physical activity intervention studies found that the majority reported significant increases in physical activity similar to those seen in print-based interventions when the content was delivered in a physical form, supporting the idea that the internet is an effective channel for physical activity promotion (Joseph, Durant, Benitez, & Pekmezi, 2014). Greater effects on behavior were also seen with the incorporation of more behavior change techniques, greater opportunities for participant interaction with the content, and utilization of theory-based strategies (Webb, Joseph, Yardley, & Michie, 2010). It has also been found that tailoring intervention content through computer programming to provide information that is personally relevant to each participant is more effective at improving the desired health outcomes than non-tailored online interventions (Lustria, et al., 2013; Bock, Marcus, Pinto, & Forsyth, 2001; Rothert, et al., 2006). Implementation of digital physical activity interventions can range from 6 weeks to 12 months, with varying degrees of resources required to continue the intervention for the designated time span (Lustria, et al., 2013; Webb, Joseph, Yardley, & Michie, 2010). Although a longer intervention period is sometimes necessary to facilitate psychological and behavior changes, it is not always feasible for participants to adhere for the desired length of time. Many factors influence retention, but an analytic review found that the average attrition for internet-based physical activity interventions was 22% (Joseph, Durant, Benitez, & Pekmezi, 2014). This suggests that although online interventions can be effective in reaching large populations and can be considered more accessible, there are still problems that need to be addressed to improve participant adherence.

Therefore, the purpose of the Daily Activity Motivation Study (DAMS) was to examine the impact of brief online modules that emphasized the immediate benefits of being active and broadened the definition of physical activity on psychological variables and physical activity behavior. Online interventions are increasingly being used as a way to increase reach of behavior change interventions, but the minimal dose required to stimulate a sustainable change in physical activity behavior remains unknown. This four-week intervention incorporated SDT-based strategies to promote autonomy and competence and examined whether this short intervention length would be sufficient to promote a change in physical activity behavior. Specifically, the intervention aimed to re-frame participant perceptions of physical activity as something that is feasible to incorporate into the day and advocated for the immediate affective outcomes of physical activity participation. Impact on participant motivation, attitudes, exercise identity, perceived behavioral control, intentions, and physical activity behavior were assessed. The hypothesis was that those who completed the DAMS interactive and autonomy-supportive modules would experience greater increases in the psychological factors associated with physical activity and larger increases in physical activity behavior compared to participants who received only the information-based modules.

Chapter 3 - Methods

Participants

Inclusion Criteria

This intervention was designed for adults between the ages of 22-45 years who were not currently pregnant or planning to become so in the next six weeks, had no limiting health conditions, felt comfortable completing program materials in English, had reliable internet access, and were not currently participating in a physical activity routine. Screening for current physical activity utilized the Transtheoretical Model (TTM) five stages of change, which served as an indicator of one's current physical activity or their preparedness to make a behavior change (Haakstad, Voldner, & Bo, 2013). Participants selected the response which most represented their current physical activity status. Those who selected stages 1-3 (*Not active and not planning to change, not active but have thought about changing*, or *are currently active occasionally but have been thinking about specific activities to begin in the near future*) were included in the study. Those who self-identified as being in stage 4 (*currently active most days but have only begun doing so in the last six months*) or stage 5 (*active most days and have done so for more than six months*) were excluded from the study.

Recruitment

Participants were recruited through online social media postings, university listserv email distributions, daily digital university newsletter, flyers, and through local community media channels. Two waves of the study were conducted: one beginning in October 2017 and another in January 2018. Interested individuals were directed to the baseline survey hosted on the Qualtrics platform. Upon providing informed consent and meeting the inclusion criteria, participants entered their contact information and completed the baseline measures.

Intervention

Procedure

After successful completion of all baseline measures participants were randomized into the intervention group, where they received more interactive and autonomy supportive modules, or the information-based control group. Each participant received four total modules, with each module designed to take approximately 10 minutes to complete. Modules were emailed to participants on Monday mornings and participants were asked to complete each module within one week. Reminder emails were sent on Friday mornings to those who had not yet completed the weekly module. The post-intervention survey was emailed the Monday immediately following the final module and remained open for 2 weeks to assure adequate time to complete the post-intervention assessment. All modules and pre-post surveys were completed via the Qualtrics online survey platform.

DAMS Study Content Overview

The overarching purpose of the DAMS study was to enhance autonomous motivation to be physically active by re-framing participant perceptions of physical activity to help participants develop a new perspective towards physical activity. There were four topics addressed in the modules: the benefits of physical activity, the physical activity guidelines, making a plan to increase physical activity, and addressing environmental and external influences on one's physical activity behavior. Each weekly module also included an additional activity to be completed by the participant before receiving the next weekly module. A more detailed description of the module topics and the tasks can be found in Table 3-1.

Table 3-1: Module Content Overview

	General Topic	Intervention	Control
Module 1	❖ The reason 'Why' ❖ Benefits	• Why do you want to be active? • Past & current experiences with physical activity • Benefits of being active (distal & proximal)	Benefits of Physical activity - 4 categories: • Disease Prevention • Physical Health • Mental Health • Overall Quality of Life
Post-module activity		Type 3 reasons why you want to be more active	Pick 3 benefits from the list to focus on
Module 2	❖ Re-defining Exercise ❖ The 'How'	• Personal definition of exercise vs. physical activity • Physical Activity Guidelines • Tips to get more activity in daily routine	• Physical Activity Guidelines (moderate vs. vigorous activity) • 10-minute rule; what 'counts' • Tips to get more activity into the day
Post-module activity		Identify and plan specific activities to incorporate into daily routine	Identify activities that could incorporate into daily routine
Module 3	❖ Self-regulation ❖ Barriers	• Set activity intentions (what, where, when, how many days) • If… Then… Planning • Other tips for staying active	Description of common barriers and general advice on how to overcome: • Lack of time • Not motivated • Fear of injury • Lack of resources • Not knowing what to do
Post-module activity		Complete the planning sheet to identify what, when, where, and how they feel before & after being active	Identify 2 barriers and think of a possible contingency plan
Module 4	❖ External Influences ❖ Social Support	• Reflection on perceived personal behavior control • Completed a personal version of the socio-ecological model of influence • Emphasized the importance of prioritizing self-care	Defined 4 types of Social Support: • Informational • Emotional • Instrumental • Appraisal Described common external influences and community resources
Post-module activity		Identify ways to enhance environment support and make necessary changes	Identify ways one could potentially enhance environment support
		* Extra bonus: share some of the information learned w/ others	

Intervention Content

The intervention modules incorporated various strategies to support autonomy and competence by encouraging participants to identify how the content being presented could be incorporated into their daily lives. This approach was different than previous interventions that provided information but did not help individuals figure out how to integrate the information into their lives. At the beginning of each intervention module, participants were prompted to reflect on their current status related to that week's topic and type their responses. For example, in Module

1 participants were asked to list three reasons why they wanted to increase their physical activity. After completing this module that emphasized the importance of focusing on immediate affective outcomes, participants were asked the same question and reminded of their initial response. This pre-post reflection was designed to enhance participant autonomy by helping them realize that they were in control of their thoughts and could change their mindset if they wanted to. The second module aimed to increase participants' perceived competence for physical activity by emphasizing the variety of activities one can do beyond structured exercise. This module also asked participants to compare their definitions of exercise before and after completing the module and to identify places where they could sneak more activity into their day. Module 3 focused on developing a plan for overcoming barriers, and after completing the If… Then… strategy for implementing intentions participants reflected on their ability to overcome barriers in the future (Gollwitzer & Sheeran, 2006). This module enhanced competence by guiding the participants to identify how they personally could go about increasing their activity along with supporting autonomy through the development of a plan that worked for them. The last module asked participants to rate the extent to which they believed their behavior was influenced by others and to identify relevant social, community, organizational, environmental, and policy influences on their physical activity behavior within the context of the Socio-Ecological Model (Mcleroy, Bibeau, Steckler, & Glanz, 1988). This final module also concluded with information on the importance of self-care and prioritizing oneself at the center of the model to boost individual sense of autonomy. All the strategies utilized in the intervention modules have been classified based on the taxonomy of behavior change techniques described by Michie, et al., 2013 and can be found in Table 3-2.

Each module also included a weekly 'bonus' activity for participants to practice applying the information from the module to their lives. Participants either selected "I promise" to complete the activity, or "I cannot promise this to myself at this time". This option to make a promise facilitated autonomy by offering a choice and avoiding a sense of imposed external obligation associated with a more controlled source of motivation. Bonus activities for the intervention group included creating a more detailed rationale for why they wanted to be more active, scheduling additional activity into their day, filling out a downloadable planning worksheet, and taking action to change something in their environment that they had identified as being unsupportive of physical activity.

Table 3-2: DAMS Strategies

Techniques classified according to Michie, et al., 2013

Strategy	Behavior Change Technique	Related Activity in Daily Activity Motivation Study (DAMS)	Module(s) Implemented	SDT Construct(s) Targeted:
1.2	Problem Solving	If… Then… Planning	3	Competence
1.4	Action Planning	Identify activities + When, Where, How many days	3	Competence, Autonomy
1.9	Commitment	Bonus Activity Promises	1, 2, 3, 4	Autonomy
2.3	Self-Monitoring of Behavior	Downloadable Planning/tracking sheet	3	Competence
5.1	Information about health consequences	Infographic of various benefits of physical activity (PA)	1	Autonomy
5.4	Monitoring of emotional consequences	Participants identified short-term benefits of PA	1	Competence Autonomy
5.6	Information about emotional consequences	Description of emotional benefits of PA	1	Competence Autonomy
10.7	Self-Incentive	Encouraged to make time for self-care & prioritize PA	4	Autonomy
11.2	Reduce Negative Emotions	Encouraged to be non-judgmental, be flexible, accept lapses, not an easy process	3	Autonomy
12.2	Restructuring Social Environment	Identified ways to increase social support	4	Relatedness Autonomy
13.2	Framing/Reframing	Defined PA vs. exercise; abolished 10-minute 'all-or-nothing' rule	2	Autonomy Competence
15.3	Focus on past success	What activities have completed in the past	1	Competence Autonomy

Control Content

The control group received information similar to the intervention group, including the benefits of being active and ideas on how to get more activity into one's day. However, there were a few differences between the modules. The first difference was that participants in this group were instructed to think about the content but were not offered a tangible place to record their thoughts within the module. Additionally, the content was presented more matter-of-factly regarding how and why they should be more active and in a less autonomy-supportive manner than the information was framed for the intervention modules. One example of this difference is that the tasks presented at the end of the control modules were presented as mandatory tasks instead of optional activities that the intervention participants could choose to complete.

Measures

Demographics

Demographic information collected included the following: sex, age, race, ethnicity, education, annual income, marital status, number of children and corresponding ages (as applicable).

Autonomous Motivation

Motivation for physical activity was assessed using version 3 of the Behavioral Regulations in Exercise Questionnaire (BREQ-3) (Markland & Tobin, 2004; Wilson, Rodgers, Loitz, & Scime, 2006). This scale includes the assessment of integrated motivation in addition to the subscales of amotivation, extrinsic, introjected, identified, and intrinsic motivation assessed in previous versions. Motivation was assessed by asking participants the extent to which each of the 24 statements was true for them, and responses were indicated on a five-point Likert scale (*1 = Not true for me, 5 = Very true for me).* Examples of statements for each type of motivation include: Amotivation ("*I don't see why I should have to exercise*"); External ("*I exercise because other*

people say I should"), Introjected ("*I feel guilty when I don't exercise"*), Identified ("*It is important for me to make the effort to exercise regularly"*), Integrated ("*I consider exercise consistent with my values"*), and Intrinsic (*"I exercise because it's fun"*). Items for each subscale were averaged to create total subscale scores for each source of motivation, and Cronbach's alpha reliability coefficients exceeded .75 for all subscales except Identified (α = .639).

In addition, the Relative Autonomy Index (RAI) was calculated to assess participant levels of autonomous motivation (Markland & Tobin, 2004; Wilson, Rodgers, Loitz, & Scime, 2006). RAI was calculated by weighting the average scores for each subscale and summing the weighted values to calculate one RAI index. Higher, more positive scores indicate greater levels of autonomy.

Exercise Identity

Exercise Identity was assessed using the 9-item Exercise Identity Scale (EIS) (Wilson & Muon, 2008; Anderson & Cychosz, 1994). Participants responded on a seven-point Likert scale (*1 = Strongly Disagree, 7 = Strongly Agree)* to items such as "*I consider myself an exerciser", "Physical exercise is a central factor to my self-concept",* and *"I would feel a real loss if I were forced to give up exercising".* Likert responses were summed to create one identity score, where larger scores indicated a greater sense of associating exercise with one's identity. Internal consistency estimates were of an acceptable level (α=.869).

Attitude towards Physical Activity

Attitude was assessed using a 10-item questionnaire modified from Nelson, Benson, & Jensen (2009) and Motl, et al. (2000). Five items represented a positive attitude (i.e. *"... it would improve my mood")* and five represented a negative attitude (i.e. "*…it would be painful")* toward physical activity. Participants were asked to rate their agreement on a five-point Likert Scale (*1*

= "Strongly Disagree"; 5 = "Strongly Agree"). Separate positive and negative attitude scores were calculated by summing scaled responses. Total attitude was calculated by reverse-scoring the negative attitude responses and summing all 10 response-scores. Possible scores on the sub-scales ranged from 5-25, and possible combined attitude scores ranged from 10-50. Internal consistency was at an acceptable level for both negative (α=.737) and positive (α=.769) attitude scales.

Perceived Behavioral Control

Perceived Behavioral Control (PBC) was assessed through five items. Three of the five items utilized the scale developed by Motl, et al. (2000) that involved rating agreement with the statements "*I have control over my being physically active on most days", "I believe I have all the things I need to be physically active on most days",* and "*If I want to be I can be physically active on most days"*. The remaining two items asked participants to rate the difficulty of *"being physically active on most days"* and *"adopting a physically active lifestyle"* on a five-point Likert Scale (*1 = Very Difficult, 5 = Very Easy*). Total PBC was calculated by summing all responses, with higher scores indicating greater perceptions of control. Internal consistency across the five items was acceptable (α=.820).

Intentions

Intention to be active over the next week was measured by the question "*Please indicate the number of days you intend to take part in physical activity during the next week*". Options ranged from 0-7 days.

Physical Activity (via 7-day Modifiable PAQ)

Physical activity was assessed using the Modifiable 7-day Physical Activity Questionnaire (MAQ) (Pettee, McClain, Schmid, Storti, & Ainsworth, 2011). Participants were asked to report

the number of minutes they spent per day over the last week engaging in activities from a list of 28 total activities (e.g. aerobics, basketball, circuit training, strength training, bicycling, and gardening). Activities were separated into 'Indoor' and 'Outdoor' categories to break up the question and make it easier to select the activities they engaged in. A free-response 'Other' category was also available for both activity settings. Physical activity scores were calculated by multiplying the total number of hours spent in each activity per week by the average MET value for that activity. MET values from all activities were then summed to calculate the weekly MET-hours of physical activity at each time point.

Program Evaluation

Information regarding the number of modules accessed and the amount of time spent engaged in the modules was extracted from Qualtrics. Participants were also asked to report which modules they completed and to indicate which (if any) of the take-home or bonus activities they completed in the post-intervention survey. This survey also contained a program evaluation, which asked participants to rate their agreement on a five-point Likert Scale (*1 = Strongly Disagree, 5 = Strongly Agree)* on five questions regarding their participation in the DAMS Study. Example statements included: *The DAMS Study increased my motivation to be physically active"* and *"The online modules were an effective way to deliver the content"*. Participants also answered open-ended questions, including "*Did participating in the study increase your motivation to be active on a daily basis?"*, "W*hat additional information would you have liked to see included?*", and provided suggestions for improvement.

Data Analysis

Data were analyzed using SPSS version 25 (IBM Corp, 2017). A mixed design 2 (group) by 2 (time) repeated measures analysis of variance (ANOVA) was utilized to assess changes in each

outcome over time and to determine if there were differences between each group. Program evaluation scores were averaged, and t-tests were used to determine whether the scores differed by group. Qualitative feedback was also extracted and summarized.

Chapter 4 - Results

Demographics

Participant demographics are presented in Table 4-1. Most participants were white (88%), females (83%) in the middle-upper income group (68%). The average age of participants was 33.5 ± 6.879 years. Distribution of all demographics was similar between the intervention and control group.

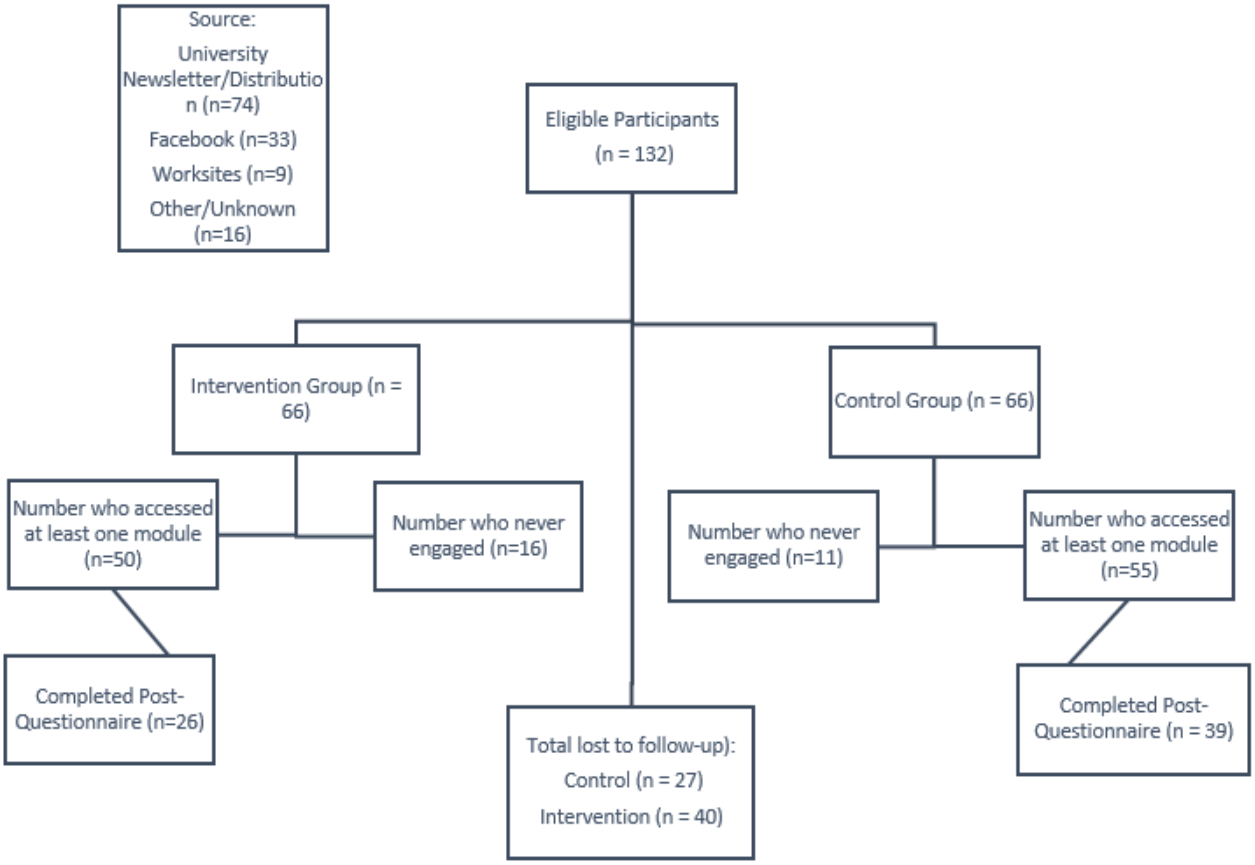
Table 4-1: Participant Demographics

Variable	*All (n=132)*	*Intervention (n=66)*	*Control (n=66)*
	N (%)	N (%)	N (%)
Stage of Change			
Stage 2 (Contemplation)	36 (27%)	21 (32%)	15 (23%)
Stage 3 (Preparation)	96 (73%)	45 (68%)	51 (77%)
Sex			
Male	23 (17%)	13 (20%)	10 (15%)
Female	109 (83%)	53 (80%)	56 (85%)
Education			
Some College	16 (12%)	11 (17%)	5 (8%)
Bachelor's	60 (45%)	27 (41%)	33 (50%)
Post-Graduate	56 (42%)	28 (42%)	28 (42%)
Income			
<$35,000	30 (23%)	15 (23%)	15 (23%)
$35,000-$75,000	45 (34%)	27 (41%)	18 (27%)
>$75,000	45 (34%)	18 (27%)	27 (41%)
Prefer not to answer	12 (9%)	6 (9%)	6 (9%)
Ethnicity			
White	116 (88%)	56 (85%)	60 (91%)
Native American	1 (1%)	1 (2%)	0 (0%)
Pacific Islander	1 (1%)	0 (0%)	1 (2%)
Other	4 (3%)	2 (3%)	2 (3%)
Black	7 (5%)	5 (8%)	2 (3%)
Asian	4 (3%)	3 (5%)	1 (2%)
Marital Status			
Single, never married	50 (38%)	28 (42%)	22 (33%)
Married	70 (53%)	30 (45%)	40 (61%)
Widowed or Divorced	12 (9%)	8 (12%)	4 (6%)
Number of Children			
0	68 (52%)	32 (48%)	36 (55%)
1	16 (12%)	10 (15%)	6 (9%)
2	30 (23%)	17 (26%)	13 (20%)
3	11 (8%)	5 (8%)	6 (9%)
≥4	7 (5%)	2 (3%)	5 (7%)

Engagement & Retention

Participant retention throughout the intervention is presented in Figure 4-1. There were 132 eligible participants who met inclusion criteria and completed all baseline measures, which resulted in randomization of 66 participants into the intervention group and 66 into the control group. There were 27 participants (16 intervention, 11 control) who were lost to follow-up between completion of the baseline survey and the beginning of the intervention who never accessed any of the content. Retention decreased at a similar rate between both groups over the four-week study and is shown in Figure 4-1. Complete pre-post data was recorded for 65 participants (26 intervention, 39 control) with an overall retention rate of 49% (65/132).

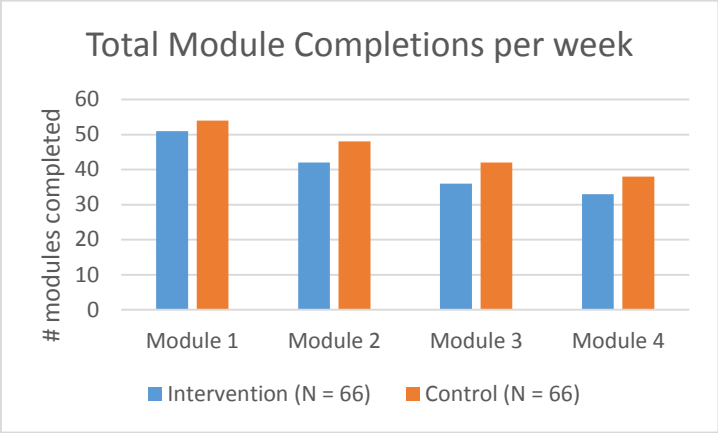
Figure 4-1: Participant Retention Flowchart



Breakdown of retention by group reveals 40% of intervention participants completed the study compared to 60% of the control group.

Cross-Tab, Chi-Square, and independent samples t-tests comparing participants who completed both pre and post-intervention assessments to those who did not complete the post-intervention assessment yielded no significant differences in demographics or baseline scores for all measured outcome variables.

Figure 4-2: Total Module Completions per week



Average length of time to complete each of the modules was calculated. Participants whose module completion time exceeded 45 minutes were excluded from the average duration calculation since it is unlikely a duration exceeding this length is reflective of active interaction with the module. Participants in the intervention group spent an average of 11.71 (±7.64) minutes per module, while the control group spent 7.76 (±8.36) minutes per module. An independent t-test determined that these time differences were significant [$t(3)=7.19$, $p=.005$].

Table 4-2: Intervention Bonus Activity Promises and Completion

	Total # responses	N (%) promising	N (%) Completing*
Module 1	51	42 (82.4%)	24 (57%)
Module 2	42	37 (88.1%)	19 (51%)
Module 3	36	18 (50.0%)	13 (72%)
Module 4	32	19 (59.4%)	12 (63%)

*Completion percentage based on the number who promised

The last measure of engagement was completion of the bonus activities. Table 4-2 presents the number of participants who promised to complete the bonus activity for each module, and the number of participants who reported completing the bonus activity on the post-intervention survey. The control group did not

indicate their intention to complete the assigned activities between modules, therefore follow-through cannot be assessed. When calculating completion of the take-home activities for both groups, 20% of those completing the post-intervention survey reported completing all four of the take home activities, 43% completed between one and three activities, and 35% completed none.

Psychological and Behavioral Outcomes

Descriptive statistics from baseline to post-intervention are presented in Table 4-3.

Table 4-3: Psychological Outcomes

Measure [Possible Range]	Group	Baseline Mean (SD)	Post-Intervention Mean (SD)	N	P-value (Time)	P-value (Group)
Relative Autonomy Index	Control	6.781 (5.738)	8.57 (5.099)	n=40	<.001*	.515
	Intervention	6.437 (5.868)	8.928 (5.341)	n=28		
Exercise Identity [9-63]	Control	29.84 (9.466)	31.82 (11.53)	n = 39	.079	.835
	Intervention	30.67 (11.31)	33.036 (12.468)	n = 28		
Attitude (Combined) [-20 - +50]	Control	5.05 (6.13)	6.07 (5.78)	n = 39	.033*	.881
	Intervention	3.82 (5.42)	5 (4.77)	n = 28		
Perceived Behavioral Control [5-25]	Control	15.65 (4.19)	17.67 (3.54)	n = 40	.002*	.206
	Intervention	17.75 (3.56)	18.6 (2.64)	n = 28		
Intention (# days) [0-7]	Control	3.23 (1.24)	3.3 (1.3)	n = 39	.448	.763
	Intervention	3.28 (1.18)	3.46 (.83)	n = 28		
MAQ (MET-hours)	Control	13.44 (12.57)	17.91 (15.99)	n = 37	.154	.514
	Intervention	18.59 (16.25)	20.25 (13.78)	n = 24		

* denotes significance at α=.05

Positive changes were seen across both groups for most variables over the four weeks, with significant improvements in autonomous motivation [$F(1,66)=16.207$, $p=<.001$], negative attitude [$F(1,65)=7.663$, $p=.007$], total attitude [$F(1,65)=4.726$, $p=.033$], and perceived behavioral control [$F(1,66)=9.191$, $p=.002$]. Intentions and physical activity behavior did not change significantly from pre to post-intervention. There were no significant differences between

the intervention and control group on any of the psychological outcomes assessed or physical activity.

Motivation Subscales

Mixed 2x2 ANOVAs were conducted to investigate any changes in the motivation subscales, and results are presented in Table 4-4. Significant improvements between time points were found for identified [$F(1,66)=7.818$, $p=0.007$], integrated [$F(1,66)=17.51$, $p=<.001$], and intrinsic motivation [$F(1,66)=15.521$, $p=<.001$]. Between groups there were significant differences for external [$F(1,66)=4.022$, $p=0.049$] and integrated [$F(1,66)=5.541$, $p=0.022$] motivation. Both groups experienced an increase in integrated motivation, with the intervention group having a larger increase. External motivation increased in the intervention group from pre-post intervention whereas it decreased in the control group.

Table 4-4: Motivation Subscale Outcomes

	Group	Baseline M (SD)	Post M (SD)	N	F (Time)	P-value (Time)	P-value (group)
Amotivation	Control	0.26 (.45)	0.25 (.46)	n=40	0.551	0.46	0.666
	Intervention	0.35 (.58)	0.29 (.41)	n=28	0.188		
External	Control	1.0 (.88)	0.83 (.81)	n = 40	0.055	0.816	0.049*
	Intervention	0.95 (.84)	1.16 (.82)	n = 28	4.022		
Introjected	Control	2.31 (1.03)	2.225 (1.05)	n = 40	2.717	0.104	0.43
	Intervention	2.26 (1.03)	2.02 (1.04)	n = 28	0.63		
Identified	Control	2.85 (.66)	3.05 (.55)	n = 40	7.818	0.007*	0.923
	Intervention	2.77 (.61)	2.99 (.71)	n = 28	0.009		
Integrated	Control	1.64 (.81)	1.79 (.78)	n = 40	17.51	<.001*	0.022*
	Intervention	1.45 (.802)	1.99 (1.04)	n = 28	0.022		
Intrinsic	Control	1.93 (.89)	2.2 (.81)	n = 40	15.21	<.001*	0.517
	Intervention	2.0 (.97)	2.38 (.86)	n = 28	0.424		

* denotes significance at α=.05

Program Evaluation

Average participant scores on the program evaluation questions are shown in Table 4-5. Overall program evaluations were moderate-high, and there were no significant differences in evaluation scores between groups.

Table 4-5: Quantitative Program Evaluation

Question	Control		Intervention	
	Mean*	SD	Mean	SD
The DAMS Study increased my motivation to be physically active	3.62	0.711	3.58	0.703
The content of the DAMS Study was relevant to me	4.13	0.732	4.12	0.653
The online modules were an effective way to deliver the content	4.05	0.826	4.15	0.675
The length of the modules was appropriate	4.33	0.701	4.35	0.562
I would recommend participating in the DAMS Study to others	3.77	0.872	3.96	0.916

*scores based on five-point Likert scale (*1=Strongly disagree, 5 = Strongly agree)*

Responses to the open-ended evaluation questions were analyzed for themes and comparisons were made between groups. When asked *"Did completing the DAMS Study modules increase your motivation to be physically active on a daily basis?"* there were common themes that emerged between groups. More individuals in the control group said it did not increase their motivation than those in the intervention group; however, both groups expressed the idea that a lot of the information presented was already known. Both groups also noted that the modules were a good reminder but the time of delivery and likelihood of completing them while at work resulted in in much of the content being forgotten. Suggestions for additional information to be added to the modules included: example workouts, more specific examples of exercises or recommendations to do during the day, additional take-home worksheets, and more accountability. Other suggestions to improve the study overall included the addition of opportunities to interact with other participants, incorporating more accountability, and adding videos to present the information or exercises. Some participants also stated that they would be interested in receiving content that is tailored to their personal situation instead of the more

general and overarching information that was provided. Overall feedback from participants was positive, suggesting they enjoyed the experience and were thankful for the reminders to increase their physical activity.

Chapter 5 - Discussion

The purpose of the DAMS Study was to examine the impact of a brief, autonomy-supportive intervention that sought to re-frame perceptions of physical activity as compared to information-based modules on several psychological variables and physical activity behavior. It was hypothesized that participants completing the more interactive SDT-based intervention modules would experience greater improvements in the psychological outcomes as well as levels of physical activity than those receiving information only. Results indicated there was a significant increase in the level of autonomous motivation, total attitude towards physical activity, and perceived behavioral control from pre-post intervention for both groups, along with a significant decrease in negative attitudes toward physical activity. However, physical activity did not change significantly during the four-week intervention. One possible explanation is that physical activity behavior was assessed immediately following the intervention, with the 7-day MAQ post-intervention data reflecting participant activity during the final week of the intervention. It is plausible that there was an insufficient amount of time for the psychological factors, which are typically considered precursors to behavior, to be translated into a measurable behavior change. This translation to behavior is alleged to occur through self-regulation techniques, with some research suggesting that self-regulation is a key mediator in bridging the gap between intention and behavior (Segar, Eccles, & Richardson, 2008). Self-regulation was not directly assessed in this study, but participants were provided with prompts to develop an exercise plan and identify opportunities in their daily routine to promote self-regulatory behaviors.

The hypothesis that the incorporation of autonomy-supportive reflection questions in the DAMS modules for participants to identify how to implement the content in their lives would lead to greater increases in all measured outcomes relative to an information-only control

condition was not supported. The similar increases seen in the control group were unexpected as previous studies have shown that education-based interventions typically are not as effective as those incorporating more interactive or theory-based behavior change strategies (Sherwood & Jeffery, 2000; Silva, et al., 2010; Rothert, et al., 2006). One possible explanation for the unexpected increase in the control group is that many of the recommendations for re-framing physical activity were included in both the DAMS modules and control modules. The messages conveyed the central idea that physical activity is something that is feasible to incorporate into the day and can have immediate positive impacts, which was in line with many of the recommendations made by previous studies (Segar, Eccles, & Richardson, 2011; Berry & Latimer-Cheung, 2013; Ekkekakis, 2013; Segar, Guerin, Phillips, & Fortier, 2016). Although the specific message framing differed between groups, similar information regarding the benefits of physical activity, different activities that 'count' towards the weekly recommendations, ideas to overcome common barriers, and the influence of external factors was presented to both groups. It is also possible that participants in the control group were more likely to remain engaged in the study because their tasks were presented as mandatory. This sense of commitment could also explain the greater retention seen among this group; however, the control group reported a decrease in external motivation whereas an increase in external motivation was found in the intervention group. A possible reason for this phenomenon is that participants in the intervention group felt obligated to complete the within-module activities as well as the bonus activities that they had made a promise to complete.

This study also sought to assess if online modules were an effective method of delivering autonomy-supportive content. The DAMS modules included pre-post module reflection questions along with other interactive components built into each module to support autonomy.

Although these components likely played a key role in increasing participant autonomy, they also resulted in the DAMS modules being more time-consuming for participants to complete. The intervention modules took an average of four minutes longer to complete, which was a statistically significant greater amount of time. The additional time could be the reason only 40% of those randomized into the intervention group completed the post-intervention assessments as compared to 60% of participants randomized into the control group. Although longer modules are to be expected with the incorporation of SDT-based activities in the intervention modules, the additional time seemed to negatively impact adherence.

Another overarching question this study sought to answer is whether minimal intervention time (i.e. 30-40 total minutes over 4 weeks) is enough to spark a change in psychological influences and physical activity behavior. Previous interventions utilizing theory-based strategies have been more resource-intensive, often requiring in-person counseling or greater demand on the researchers to manage the intervention (Bock, Marcus, Pinto, & Forsyth, 2001; Fortier, Duda, Guerin, & Teixeira, 2012; Segar, Jayaratne, Hanlon, & Richardson, 2002). Results from this study suggest that a brief online intervention can lead to positive changes in the psychological variables; however, it remains unknown whether these changes were sustained or if they were later translated into physical activity behavior. Future studies would benefit from following up with participants in the months after the intervention to assess whether the changes in the psychological variables would be translated to behavior as well as if the positive changes in the psychological factors were maintained.

This study is not without limitations, with the most notable being the size and representativeness of the study sample. Recruitment yielded a rather small group of participants that consisted primarily of white, well-educated women. Future studies utilizing online

intervention content would benefit from identifying strategies to effectively recruit a more diverse population, particularly males. Additionally, the four-week duration of the intervention may not have been enough time for the psychological changes to become a fully internalized. Furthermore, all data presented was entirely self-reported, which increases the potential for bias.

Another limitation was the time constraints for the study itself, as the short duration of time available to design and implement the intervention did not allow time for the modules to be tested and revised before delivery. Future interventions utilizing online modules could benefit from incorporating some feedback from the present study. Notable suggestions for improvement include: additional communication between modules, increasing participants' sense of accountability, incorporating additional physical activity logs, and possibly providing an opportunity to interact with other participants. Enhancing participant engagement through these suggestions as well as incorporating computer programming strategies to tailor the intervention content to each participant could enhance participant retention. The presentation of personally relevant information has been found to increase engagement in the content along with increased motivation to act on the information presented (Lustria, et al., 2013). Tailoring the content to individuals would enable participants to receive information they are more likely to consider valuable and personally relevant, which increases the likelihood of continued participation in the intervention.

There are also some strengths to this study. To our knowledge this study is one of the first to test the influence of a rather brief autonomy-supportive web-based intervention on psychological factors associated with physical activity. Additionally, the content of the modules broadly defined physical activity as a feasible, enjoyable activity and emphasized the immediate benefits of being active consistent with previous research on effective strategies for facilitating

behavior change. The positive findings related to the psychological factors suggest that utilizing an online platform to prompt individuals to re-frame their perceptions of physical activity can be an effective strategy. Future studies are needed to confirm and expand on the present findings, but there is a possibility that utilizing strategies like those presented here could be a promising mechanism to promote physical activity on a larger scale.

Conclusion

Online interventions promoting physical activity are a promising intervention strategy to enhance the psychological factors associated with sustained physical activity behavior. In the present study there were no differences in the psychological changes experienced by participants in the interactive and information-based groups; however positive changes were seen in autonomous motivation, attitude, and perceived behavioral control over time. Updating the way in which physical activity is presented to incorporate associations with theoretical constructs and the core psychological needs identified by SDT can enhance autonomous motivation and perceived competence. Support for these essential needs increases the likelihood that individuals will be able to sustain a physically active lifestyle. An online strategy is a promising and feasible way to address the psychological barriers associated with the physical inactivity problem, and future interventions should aim to refine the present approach and seek strategies to increase the generalizability of the intervention.

Chapter 6 - References

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