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A Digitial Health Action Process Approach Intervention to Promote Resistance Training in Healthy Adult Novices

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A DIGITIAL HEALTH ACTION PROCESS APPROACH INTERVENTION TO PROMOTE

RESISTANCE TRAINING IN HEALTHY ADULT NOVICES

A Dissertation Presented

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A DIGITIAL HEALTH ACTION PROCESS APPROACH INTERVENTION TO PROMOTE

RESISTANCE TRAINING IN HEALTHY ADULT NOVICES

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by
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ABSTRACT

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Introduction: There is little research to date that has been conducted testing theory-based interventions to increase resistance training. We assessed the relative efficacy of Health Action Process Approach (HAPA) based digital intervention for performing resistance training (RT). **Methods:** The RTinHome study was a three-phase study which recruited adults aged 18-35 not meeting the strength training recommendations. In Phase I, all participants received two Zoom based training sessions over a one-week period. In Phase II, participants were randomized to a no contract control or to a 4-week, HAPA based digital coaching intervention. In Phase III

(follow-up) there was no contact with all enrolled participants for four weeks. Attitude and self-efficacy were assessed after the first training session in Phase I. Attitude, self-efficacy, coping planning, behavioral expectations, and intention were assessed at the end of Phase I, at the end of Phase II, and at the end of Phase III. A structural equation model was fit to each data collection point to test treatment effects on behavior. It was hypothesized that the intervention would have positive effects on behavior at the end of Phase II and III. **Results**: There were significant resistance training behavioral differences between the groups, favoring the intervention group, at the end of Phase II in adherence for both the previous week (last 7 days) (.50 SE=.24; p=0.040) and the previous four weeks (1.92 SE=.90; p=0.033) but not during Phase III. From Phase I to Phase II the intervention had significant effects on self-efficacy (.68 SE =.26), intention (.77 SE=.27), behavioral expectations (19.7 SE=5.3), and coping planning (.43 SE.13). Changes in self-efficacy (2.07 SE=0.83) and intention (3.0 SE=.61) had significant effects on RT behavior at the end of Phase II. In a multiple mediation model, intention mediated the effects of the intervention in Phase II (2.64 SE=.83). **Conclusion:** The intervention had effects on RT behavior at the end of Phase II but group differences were no longer significant at the end of Phase III.

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CHAPTER 1

INTRODUCTION

Physical inactivity is a major contributor to premature global mortality, contributing to 6% of deaths (WHO, 2010). Physical activity is defined as any bodily movement produced by skeletal muscles that results in energy expenditure (Capersen, Powell, Christenson, 1985). Exercise is a subcategory of physical activity that is planned, structured, and repetitive and is performed with the objective of maintaining or improving physical fitness (Capersen, Powell, Christenson, 1985). Resistance training is a form of exercise that has been shown to improve bone mineral density, lean body mass, strength and endurance, and insulin sensitivity, while decreasing blood pressure, improving lipid profiles, and reducing the risk of diabetes (Westcott, 2012). Resistance training also reduces the risk of falls, osteoarthritis, and body fat levels (Hass, Feigenbaum & Franklin, 2001; Westcott, 2012). Resistance training has been shown to improve depressive symptoms (Gordon et al., 2018). Adults aged 18-65 are encouraged to engage in resistance training two times per week (US Department of Health and Human Services, 2018). In 2011, the CDC added to their reporting on the prevalence rates of physical activity by also including resistance training. In 2011, 29.3% of the population was meeting the recommendations. In 2013, 2015, and 2017, 29.6%, 30.4%, and 30.5% of the population was meeting the strength training recommendations respectively (Centers for Disease Control and Prevention [CDC], 2017). This data includes the use of yoga, sit-ups or push-ups and those using weight machines, free weights, or elastic bands as methods of strengthening muscles (CDC, 2017).

Due to widespread failure to engage in, maintain, or achieve adequate amounts of resistance training, efficacious and theory-based interventions which address determinants of behavior are needed to promote resistance training. Social-cognitive variables that have been shown to contribute to resistance training participation include self-efficacy, intention, attitudes, outcome expectations, perceived behavioral control, and self-regulation (Rhodes et al., 2017). Resistance training studies using theories, such as the Theory of Planned Behavior (TPB) (Bryan & Rocheleau, 2002; Courneya et al., 2004), Protection Motivation Theory (Plotnikoff et al., 2009), and Social Cognitive Theory (Gao & Kosma, 2008), place intention as the most proximal predictor of resistance training participation.

As an intrapersonal cognitive variable, intention strength has been shown to have positive impacts on a wide variety of health promotion behaviors such as physical activity, sunscreen use, breast self-exams, and flossing (Webb & Sheeran, 2006; Sheeran, 2002). It has been observed that approximately one-third of individuals who hold positive intentions to be physically active do not act on these intentions (Godin & Conner, 2008). On the other hand, only 4.5% of individuals with negative intentions to be physically active engage in physical activity. Thus, while intention is likely a necessary precondition for engaging in physical activity it may not adequately explain why a behavior such as physical activity would occur (Godin & Conner, 2008). A possible explanation for this discrepancy is that other psychosocial variables could mediate the intention-behavior-relationship. This intention-behavior relationship seen with aerobic exercise may also offer insight into the intention to resistance training behavior as well. The studies proposed in this dissertation will examine if other psychological variables contribute to explaining the intention-behavior gap in resistance training.

Rationale

   Although initially limited to the advancement of aerobically based physical activity,

recommendations by prominent health organizations have begun to include resistance training

(US Department of Health and Human Services, 2018). It has been well established that

resistance training is a form of exercise that provides numerous health benefits (Westcott, 2012)

and that despite these benefits, the percent of the population that engages in resistance training is

low (CDC, 2017). The percent of adults meeting the resistance training guidelines (30.5%; CDC,

2017) is also significantly less than those meeting the 150 minutes of aerobic exercise guideline

(50.3%; CDC, 2017). Strength training provides certain benefits that aerobic physical activity

does not (Westcott, 2012). A consistent trend that has occurred since data has been recorded is

that as the categories for age increase, the percent of individuals who meet the guidelines

decreases (CDC, 2017). Furthermore, the steepest decline in participation occurs as individuals'

transition from the 18-24 category (45.6%) to the 25 to 34 category (37.1%; CDC, 2017).

   Participating in physical activity has intrapersonal psychological determinants including

self-efficacy, intention, self-monitoring, planning, attitudes, outcome expectations, and perceived

behavioral control (Choi, Lee, Lee, Kang & Choi, 2017; Belanger-Gravel, Godin & Amireault,

2013; Karoly, Ruehlman, Okun, Lutz, Newton, & Fairholme 2005; Rovniak, Anderson, Winett,

& Stephen, 2002; Sherwood & Jeffery, 2000). Resistance training requires equipment,

knowledge of how to execute a technique, an efficient workout design, and therefore, may be

more complex than going for a walk, jog, or bike ride. Given the important health benefits and

low prevalence rates, it is imperative to know which psychological constructs contribute to

participation and which constructs when enhanced contribute to greater participation. Thus, to

improve interventions, determinants of behavior need to be identified, and behavior change

techniques that enhance these determinants need to be examined and then utilized (Kok et al.,

2016, Kok, 2014). Appropriate behavior change techniques must also be based on a sound theoretical background.

Correlates of Resistance Training Participation

Several intrapersonal psychological variables have been addressed from numerous theoretical backgrounds to explain resistance training participation. These variables have included self-efficacy, perceived behavioral control (PBC), attitudes, outcome expectations, intention, and self-regulation (Rhodes, Lubans, Karunamuni, Kennedy & Plotnikoff, 2017). In brief (see Chapter 2) fourteen self-efficacy studies showed positive relationship with resistance training behavior and intention and four showed no relationship. Eight studies showed positive relationship with PBC and resistance training behavior or intention and one showed no relationship. Seven studies that examined attitude, showed positive associations with intention or behavior and three studies showed no association. For outcome expectations, eight studies showed positive associations with intention or behavior and four studies showed no association. For intention, ten studies showed positive relationships with resistance training and three showed no relationship. All seven studies that examined self-regulation showed positive associations with behavior.

Similar to aerobic activity participation, intention seems to be an important construct for resistance training participation (Vallerand et al., 2016; Forbes et al., 2015; Rhodes, Blanchard, & Matheson, 2007; Gao, Hannon & Yi, 2007; Courneya et al., 2004; Bryan & Rocheleau, 2002). However, several studies have found no associations (Lubans et al., 2012; Plotnikoff et al., 2008) or indirect associations (Paech & Lippke, 2017). Therefore, a gap between intentions and behavior has been identified. Having a positive intention does not always translate to behavior.

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Behavioral Theories

Several prominent theories have been used to describe resistance training participation. The Transtheoretical Model (TTM) of Behavior Change, the Theory of Planned Behavior (TPB), and Social Cognitive theory (SCT) are the most frequently used. While intention seems to be a precondition for behavior to occur (Vallerand, Rhodes, Walker, & Courneya, 2016; Williams, Dunsiger, Davy, Kelleher, Marinik, & Winett, 2016; Rhodes et al., 2007), most studies have been unable to explain a large portion of the variance in behavior with intention alone. If intention fails to explain a substantial portion of behavior, models with post intentional constructs such as self-regulation may be useful for research and practice. Each resistance training study that has included a self-regulatory (N=7) component such as planning, or goal setting has found positive associations with behavior. Furthermore, self-regulation strategies such as planning are positively modifiable through interventions with changes in planning being associated with changes in behavior (Williams et al., 2016).

Several theories address the translation of intention into behavior. Of those, the Multi-Action Process Control Framework (M-PAC) (Vallerand et al., 2016) and Health Action Process Approach (HAPA) (Paech & Lippke, 2017) have been used in resistance training studies. The M-PAC framework suggest high levels of self-efficacy are needed to translate intentions into behavior (Rhodes & Yao, 2015). The HAPA suggests that maintenance self-efficacy, which involves overcoming barriers, and recovery self-efficacy, which involves performing behavior after relapses, help to translate intentions into behaviors (Rhodes & Yao, 2015). Intentions are also translated to behavior with the use of action planning and coping planning (Rhodes & Yao, 2015).

The HAPA and the M-PAC framework are the most used intention translation models for physical activity (Rhodes & Yao, 2015). However, the HAPA (Paech & Lippke, 2017) and the

M-PAC (Vallerand et al., 2016) have both been used on one occasion for resistance training research. Self-efficacy and self-regulation strategies have been shown to be related to resistance training behavior (Williams et al., 2016; Lubans et al., 2012; Gao & Kosma, 2008; Harada, Oka, Shibata, Ota, Okada, & Nakamura, 2008). Theories that include the correlates and determinants that have been shown to relate to resistance training intention as well as self-regulation could be useful in explaining resistance training behavior.

Addressing a Critical Barrier for Progress in the Field

There is a paucity of research on the psychological determinants of resistance training participation. Beyond the limited number of correlational or longitudinal studies examining the relationships between psychosocial variables and resistance training there are very few RCT's that have attempted to intervene on psychological determinants (Williams et al., 2016; Lubans et al., 2012; Millen & Bray, 2009). With the limited number of RCT's it is challenging to determine (1) which psychological variables are subject to change (2) what are the best methods to change these variables and (3) the effects of enhancing these constructs on behavior. Within the current research on resistance training, which includes longitudinal data and RCT's, planning is an important determinant to target for behavior to occur (Williams et al., 2016; Lubans et al., 2012). Task self-efficacy and attitudes contribute to favorable intentions. Individuals may also need confidence in their abilities to overcome barriers to translate intentions into behavior.

Of the RCT's that have been conducted, none have been done with a healthy young population. RCT's have been conducted with diabetics, prediabetics, cancer survivors, and older adults. While the utility of engaging in resistance training to slow disease and age-related loss of function is necessary, it is also crucial that this form of physical activity be addressed in younger disease-free individuals to prevent negative health sequelae. A clear conceptual framework,

identification of modifiable variables, as well as the effects of modification of these variables must be addressed to understand and help design resistance training behavior change programs.

Digital Interventions

No RT research has examined a remote coaching method of delivering behavior change techniques (BCT's). However, eHealth research may provide insight on the feasibility of a digitally based RT intervention. These eHealth interventions have the capability of reaching more people than traditional face-to-face interventions in a time-efficient way (Eng, 2001). Meta-analysis suggest that internet-delivered programs have a small but positive effect on physical activity levels (Davies, Spence, Vandelanotte, Caperchione, Mummery, 2012). Furthermore, a 2012 review by Goode et al. found strong evidence for telephone-delivered physical activity interventions (Goode, Reeves, & Eakin, 2012). Thus, an internet-based coaching intervention conducted through digital platforms such as Zoom or Skype would be ideal to coach RT and to also provide individuals with behavioral coaching sessions.

Aims

The aim of the current study is to examine if a *Behavioral Coaching* intervention based on the HAPA will produce greater adherence to a digital RT routine than a *Control* group. The secondary aims of the study are to examine the mechanisms through which the intervention exerted its effects. Specifically, we seek to examine if:

- Relative to participants in the *Control* condition, participants in the *Intervention* condition would show more positive changes in the targeted putative mediators – self-efficacy, intention, behavioral expectations, and coping planning.
- Changes in self-efficacy, intention, behavioral expectations, and coping planning would be predictive of RT behavior change at the follow-up time point and

- The relative effects of the intervention on RT behavior would occur through coping planning and behavioral expectations.

We will enroll adults at a university, aged 18-35, who will be randomly assigned to either a control or self-regulation group. We have chosen to target this age range due to the decline in participation that is observed between the 18-24 group and 25-35 group. Prior to randomization, participants in both groups will complete two guided resistance sessions over the course of a week. The weekly sessions will cover a variety of full body resistance exercises. After randomization, participants in the *intervention* condition undergo the self-regulation intervention targeted at behavioral expectations and coping planning.

Specific Aims
Specific Aim 1: To assess if a self-regulation based behavioral coaching intervention can increase resistance training behavior in novice participants over the same resistance training program without behavioral coaching (control group).

Hypothesis: The *intervention* group will engage in significantly more resistance training sessions than the *control* group.

Specific Aim 2: To examine the mediating mechanisms through which the intervention exerted its effects on resistance training behavior change.

Aim 2a: To examine if the intervention group has more positive changes in self-efficacy, intention, behavioral expectation, and coping planning than the *control* group.

Hypothesis: Relative to participants in the *control* condition, participants in the *intervention* will show more positive changes in the targeted putative mediators – self-efficacy, intention, behavioral expectations, and coping planning

Aim 2b: To examine if changes in self-efficacy, intention, behavioral expectations, and coping planning predict changes in behavior.

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Hypothesis: Changes in self-efficacy, intention, behavioral expectations and coping planning will be predictive of RT behavior at the follow-up time point

Aim 2c: To examine the mechanisms through which the *intervention* exerted its effects.

Hypothesis: The relative effects of the intervention on RT behavior would occur through coping planning and behavioral expectations.

CHAPTER 2

REVIEW OF THE LITERATURE

Introduction

Behavior change refers to a long-term process characterized by initiation of a new health-promoting behavior and maintenance of this behavior over time (Lally & Gardner, 2013). Behavior change interventions attempt to change behavior by modifying behavioral determinants; modifiable psychological variables that are considered to be antecedents of behavior (Kok et al., 2016). Participating in exercise has many intra and interpersonal determinants including motivation, self-efficacy, exercise history, body weight, stress, social support, access, time constraints, and characteristics of the exercise behavior (Sherwood & Jeffery, 2000). Resistance training is a unique exercise modality that requires specific knowledge, efficacy, and equipment (Rhodes, Lubans, Karunamuni, Kennedy, & Plotnikoff, 2017). Some of the identified determinants of resistance training, to be reviewed in detail below, have included attitudes, perceived behavioral control (PBC), outcome expectations, self-efficacy, intentions, and self-regulation (Rhodes et al., 2017).

The Health Benefits of Resistance Training

As defined by Behm and colleagues (2008), resistance training, is a specialized method of conditioning that involves the progressive use of a wide range of resistive loads, including body mass, and a variety of training modalities designed to enhance health, fitness and sports performance (Behm, Faigenbaum, Falk, & Klentrou, 2008). Resistance training can help increase bone mineral density, lean body mass, strength and endurance, and insulin sensitivity, while

decreasing the risk of falls, osteoarthritis, and body fat levels (Hass et al., 2001). The National

Weight Control Registry maintains a database of individuals who have been successful in

maintaining weight loss. Most registry members (91%) reported being physically active to

maintain their weight. Of those physically active members, 24% of men and 20% of women

regularly engaged in weightlifting, making weight training a viable option to aid with weight loss

maintenance (Wing & O'Hill, 2001). A review by Westcott (2012) compares the health benefits

of resistance training to medicine. Resistance training reverses muscle loss, increases bone

mineral density, reduces body fat and the risk of type 2 diabetes, improves functional capacity,

cardiovascular health, resting blood pressure, blood lipid profiles, mental health, and can reverse

aging factors (Westcott, 2012). A meta-analysis by Gordon and colleagues (2018) observed

positive effect sizes for reductions in depressive symptoms (Gordon et al., 2018). Despite the

established benefits, the majority of individuals are not meeting the resistance training

guidelines.

The Prevalence of Resistance Training

The American College of Sports Medicine (ACSM) and the American Heart Association

(AHA) as well as the Physical Activity Guidelines for Americans (U.S. Department of Health

and Human Services) recommend that adults perform exercises to strengthen their muscles for a

minimum of two days per week (ACSM, 2009, WHO, 2020). According to the ACSM et al.

(2009), muscle-strengthening activities may include a progressive weight-training program,

weight bearing calisthenics, stair climbing, and similar resistance exercises that use the major

muscle groups. However, most Americans are not meeting these recommendations. For program

design, the ACSM recommends unilateral and bilateral single- and multiple-joint resistance

training exercises with an emphasis on multiple-joint exercises for maximizing overall muscle

strength in novice (ACSM, 2009). For novices, both free-weight and machine-based training is

recommended in a repetition range of 8 to 12 for one to three sets per exercise (ACSM, 2009). It is also recommended that novice individuals train the entire body 2 to three days per week (ACSM, 2009)

In 2011, the CDC reported the first data on resistance training prevalence rates. This resistance training data included the use of yoga, sit-ups or push-ups and those using weight machines, free weights, or elastic bands as methods of strengthening muscles (CDC, 2017). In their first survey, 29.3% of the United States population was meeting the recommendations. In 2013, 2015, and 2017, 29.6%, 30.4%, and 30.5% of the population was meeting the strength training recommendations respectively (CDC, 2017). This equates to a 0.2% increase in the prevalence rate per year. At this current rate, it would take 5 years to increase the prevalence by 1%.

When examining the CDC data delineated by age, two noticeable issues arise. The first is the decline in meeting the recommendation as age increases (Figure 1; CDC 2011 to 2017). The second is the steep decline associated with the transition from the age groups of 18-24 and 25-34 (Figure 2; CDC 2011 to 2017). Based on the data several areas exist for research. The first may be to try to increase participation in older age groups. The next may be to target young individuals to begin resistance training at an early age, prior to the steep decline in participation that occurs between the 18-24 and 25-34 age groups. Interventions for this age group could then promote maintenance-based skills, which would be useful in minimizing the decline in participation.
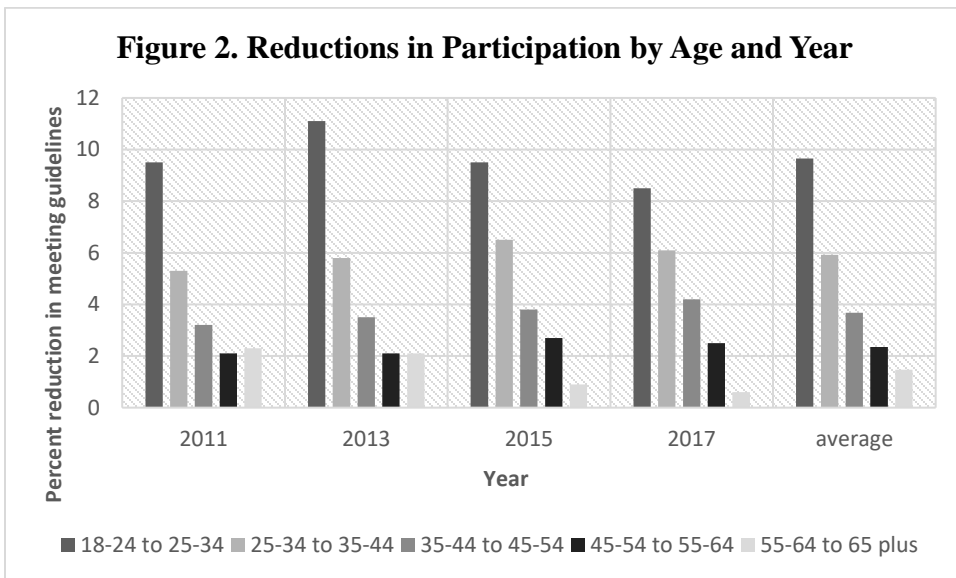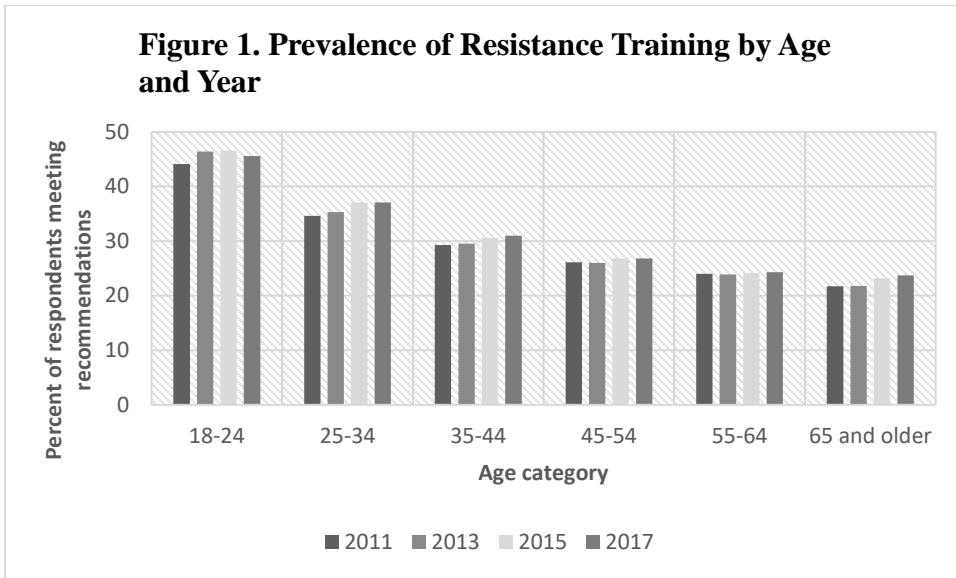
Figure 1. Prevalence of Resistance Training by Age and Year

Chart: Percent of respondents meeting recommendations (y-axis, 0–50) by Age category (x-axis: 18-24, 25-34, 35-44, 45-54, 55-64, 65 and older). Series: 2011, 2013, 2015, 2017.

Figure 2. Reductions in Participation by Age and Year

Chart: Percent reduction in meeting guidelines (y-axis, 0–12) by Year (x-axis: 2011, 2013, 2015, 2017, average). Series: 18-24 to 25-34, 25-34 to 35-44, 35-44 to 45-54, 45-54 to 55-64, 55-64 to 65 plus.

Based on the prevalence data and recommendations from leading health organizations, it appears that resistance training, despite its widespread benefits, is an underutilized form of physical activity. Because of its limited usage among various demographics, its incorporation and adoption could provide major health benefits to the population.

Theoretical Explanations of Behavior

The use of theory provides the basis for inquiry into why people may or may not engage in resistance training. Commonly used behavioral theories for physical activity in general include Social Cognitive Theory, the Theory of Planned Behavior (TPB), the Transtheoretical Model of Behavior Change, Protection Motivation Theory, and Self-Determination Theory. These theories will be reviewed, in brief, below.

Social Cognitive Theory

According to Albert Bandura's (2004), Social Cognitive Theory, learning occurs in a social context in terms of the dynamic relationship between personal factors, environmental influences, and behavior (Bandura, 2004). SCT explains how people regulate their behavior through control and reinforcement to achieve goal-directed behavior (Bandura, 2004). Self-regulation occurs through self-monitoring of behavior, its determinants and effects; through judgment of behavior in reference to standards; and through affective self-reaction (Bandura, 2004). The determinants of behavior in Social Cognitive Theory include knowledge of health risks and benefits, perceived self-efficacy that one has control over behavior, outcome expectations about the benefits and cost of behaviors, goals people set for themselves and the plans they put in place for achieving them, perceived facilitators and barriers to change (Bandura, 2004).

Theory of Planned Behavior

According to the Theory of Planned Behavior (TPB), intentions to engage in a behavior are the most proximal determinants of behavior. Intentions are dictated by attitudes, subjective norms, and perceptions of control over the behavior (perceived behavioral control). Attitudes refer to beliefs about the behavior and evaluations of the expected outcomes. Subjective norms refer to beliefs about how important others perceive the behavior in question. Perceived

behavioral control (PBC) refers to beliefs about the ease or difficulty of the behavior (Ajzen, 1991).

The Transtheoretical Model of Behavior Change

The Transtheoretical Model views behavior change as a process that involves progression through a series of stages. These stages are precontemplation, contemplation, preparation, action, and maintenance. People move through these stages of change by using behavioral and cognitive processes of change strategies. The Transtheoretical Model incorporates self-efficacy from Social Cognitive Theory. In the Transtheoretical Model, self-efficacy is situation specific confidence that people have that they can cope with high risk situations without relapsing. Decisional balance refers to the weighing of the pros and cons of change (Prochaska & Velicer, 1997).

Protection Motivation Theory

According to Protection Motivation Theory, fear appeals initiate perceptions of the severity of a threat, the probability of the threat occurring, and the efficacy of which the coping response can remove the threat. Self-efficacy has also been incorporated into protection motivation theory (Maddux & Rogers, 1982).

Self-Determination Theory

Self-Determination Theory posits that different types of motivation contribute to an individual's behavior. People may have varying levels of self-determination for certain behaviors. Controlled forms of motivation encompass behaviors done due to external pressures or through guilt whereas autonomous forms of motivation describe behaviors that are done because people value the outcome of the behavior, believe the behavior is a part of their identity, or is done because the behavior is enjoyable (Deci & Ryan, 2017).

Search Strategies

To better understand which theoretical background is appropriate for resistance training research, the determinants of resistance training were examined. A literature search was completed to examine the correlates of resistance training behavior and what determinants, constructs and theories have been utilized to explain resistance training. The current state of behavioral research in resistance training will also be presented.

In 2017 Rhodes and colleagues published a systematic review that examined the psychosocial correlates of resistance training participation. Relevant articles from this paper were examined and reference sections were screened for further articles. In addition to the articles cited by Rhodes, a literature search was conducted in the databases PsycINFO using the search terms that were correlates examined in the Rhodes article, included "resistance training" AND all relevant psychosocial variables including "self-efficacy", "risk perception", "outcome expectations", "perceived behavioral control", "intention", "self-regulation", "action planning", and "coping planning". The search was constrained to articles written after 2016 to examine if articles had been published after the Rhodes (2017) systematic review.

Results

After the removal of duplicate articles and abstract screening a total of 43 articles were examined. Of the 43 articles that were screened, 28 were included in the review. Excluded studies did not focus exclusively on resistance training or did not address intrapersonal psychological determinants of behavior. In brief (see Appendix A), of the examined studies, the following populations were used in these identified studies. Nine were conducted with college students. Outside of the college population, only two were conducted with healthy adults. Both studies were cross-sectional. Five studies were conducted with cancer survivors. Seven studies

examined older adults with ages ranging from 60.6 ± 6.1 years to 75.3 ± 7.4 years. One study

was conducted with orthopedic outpatients and one study examined pre-diabetics. Three studies

examined type II diabetics.

Theoretical Explanations of Resistance Training

An overview of the theories and constructs from the 28 identified studies reveals that, of

the examined studies, Social Cognitive Theory or Self-Efficacy Theory was the most commonly

used theory (N=8) followed by the Theory of Planned Behavior (TPB) (N=6), the

Transtheoretical Model (N=5), Self-Determination Theory (N=1) and Protection Motivation

Theory (N=1). Four studies integrated models and two did not state a theoretical background.

Appendix A contains a review of the findings in each of the studies identified. Resistance

training studies using Social Cognitive Theory examined self-efficacy (Rhodes et al., 2016;

Lubans et al. 2012; Millen & Bray, 2009; Neupert, Lachman, & Whitborne, 2009; Gao et al.,

2007, 2008), outcome expectations (Williams et al., 2016; Williams et al., 2015; Lubans et al.,

2012; Millen & Bray, 2009; Gao, Hannon, & Yi, 2007; Gao et al., 2007), intention (Williams et

al., 2016; Lubans et al., 2012) and self-regulation (Williams et al., 2016; Williams et al., 2015;

Lubans et al., 2012). Of the eight Social Cognitive Theory studies, one was cross-sectional, three

were longitudinal, one was quasi-experimental and three were RCT's. Each study utilizing Social

Cognitive Theory found some positive associations with the examined variables and resistance

training behavior.

Studies using the TPB examined attitudes (Bryan & Rocheleau, 2002; Courneya et al.,

2004; Dean et al., 2006; Forbes et al., 2015; Plotnikoff et al., 2008; Rhodes et al., 2007) , PBC

(Bryan & Rocheleau, 2002; Courneya et al., 2004; Dean et al., 2006; Forbes et al., 2015;

Plotnikoff et al., 2008; Rhodes et al., 2007), intention (Bryan & Rocheleau, 2002; Courneya et

al., 2004; Dean et al., 2006; Forbes et al., 2015; Plotnikoff et al., 2008; Rhodes et al., 2007, and

self-regulation (Forbes et al., 2015). Of the six studies using the TPB, two were cross-sectional, three were longitudinal and one was an RCT. One study (Plotnikoff et al., 2008) found that none of the measured variables explained behavior.

Studies using the Transtheoretical Model of Behavior Change assessed self-efficacy (Cardinal & Kosma, 2004; Cardinal et al., 2005; Fetherman et al., 2011; Harada et al. 2008; Ott et al., 2004) and outcome expectations (Cardinal et al., 2005; Fetherman et al., 2011; Ott et al., 2004). Of the five studies examined, three were cross-sectional and two were quasi-experimental. One study (Ott et al., 2004) found no associations with the examined variables and behavior.

The only study that utilized Protection Motivation Theory assessed behavioral intentions, self-efficacy and outcome expectations in a longitudinal design. Self-efficacy was the sole predictor of behavior (Plotnikoff et al., 2009). Two studies assessed resistance training with Self-Determination Theory. One study was a follow up to an RCT and the other was cross-sectional. Health self-determination, self-efficacy and attitudes were assessed. Self-efficacy and attitude did not contribute to resistance training participation (Van Roie et al., 2015).

Gao & Kosma (2008) integrated Self-Efficacy Theory with the TPB, Paech & Lippke (2017) integrated the Health Action Process Approach with Self-Determination Theory, Patterson et al. (2015) utilized the Integrated Behavior Change Model, and Vallerand et al. (2016) integrated the Multi-Process Action Control Framework with the TPB. Measured variables included self-efficacy (Gao & Kosma, 2008, Paech & Lippke, 2017; Patterson et al., 2015), PBC (Patterson et al., 2015; Vallerand et al., 2016) intention (Gao & Kosma, 2008; Paech & Lippke, 2017; Patterson et al., 2015; Vallerand et al., 2016), outcome expectations (Gao & Kosma, 2008), attitude (Patterson et al., 2015; Vallerand et al., 2016), and self-regulation

(Paech & Lippke, 2017; Vallerand et al., 2016). Two of these studies were cross-sectional and two were longitudinal. Each of the measured variables had some positive association with behavior or intentions.

Correlates of Resistance Training Behavior

Each of the examined theories have behavioral correlates. It is important to understand what correlates are related to behavior to determine a framework for research. The current review was able to assess six correlates of resistance training in the 28 studies. No correlate was observed in isolation; rather, most studies observed multiple correlates (i.e. attitude, PBC, intention; see Appendix A). Observed correlates of resistance training were self-efficacy (N=18), intention (N=14), attitude (N=11), perceived behavioral control (N=9), outcome expectations and related constructs (N=12), and self-regulation strategies such as planning and goal setting (N=7). These determinants will be examined in isolation; however, because each study examined multiple determinants, individual studies will be discussed in several sections.

Self-Efficacy

Self-efficacy refers to beliefs about one's capabilities to learn and/or perform specific behaviors (Bandura, 2004). The stronger the sense of self-efficacy, the more challenging the goals are that people set for themselves (Bandura, 2004). Self-efficacy was examined in 18 studies (Table 1). The populations studied included college students (N=7), older adults (N=4), diabetics (N=2), breast cancer survivors (N=2), Japanese adults (N=1), cardiac patients (N=1), and orthopedic outpatients (N=1). Fourteen studies showed positive relationship with resistance training and four showed no relationship. None of the examined studies observed a negative relationship. Three of the studies that found null results were with older adults (Fetherman et al., 2011; Jette et al., 1998; Van Roie et al., 2015) and one was done with breast cancer survivors (Ott et al., 2004). Of these studies, two did not ask participants about resistance training behavior

in the surveys used to measure self-efficacy (Fetherman et al., 2011; Jette et al, 1998). Following

will be a review of the 18 studies that included self-efficacy in their examination of resistance

training behavior.

Table 1. Self-Efficacy and Resistance Training Studies

Alphabetical List of Authors	Study Design	Population	Theory	Association*
Cardinal and Kosma (2004)	Cross-sectional	College students	Transtheoretical Model	(+)
Cardinal et al. (2005)	Cross-sectional	College students	Transtheoretical Model	(+)
Fetherman et al. (2011)	Quasi-experimental	Older women	Transtheoretical Model	( )
Gao & Hannon (2007)	Longitudinal	College students	Self-Efficacy Theory	(+)
Gao & Kosma (2008)	Longitudinal	College students	Self-Efficacy Theory integrated with the Theory of Planned Behavior	(+)
Gao et al. (2008)	Longitudinal	College students	Self-Efficacy Theory	(+)
Harada et al. (2008)	Cross-sectional	Japanese adults	Transtheoretical Model	(+)
Jette et al. (1998)	Quasi experimental	Older adults	N/A	( )
Lubans et al. (2012)	RCT	Sedentary and obese individuals with type II diabetes	Social Cognitive Theory	(+)
Millen & Bray (2009)	RCT	Cardiac patients	Social Cognitive Theory	(+)
Neupert et al. (2009)	Quasi experimental	Older adults	Self-Efficacy Theory	(+)
Ott et al. (2004)	One group pretest-posttest	Breast cancer survivors	Transtheoretical Model	( )
Paech & Lippke (2017)	Longitudinal	Orthopedic outpatients	Health Action Process Approach integrated with Self-Determination Theory	(+)
Patterson et al. (2015)	Cross-sectional	College students	Integrated Behavioral Model	(+)
Plotnikoff et al. (2009)	Longitudinal	Type II diabetics	Protection Motivation Theory	(+)
Rhodes et al. (2016)	Cross-sectional	College students	Social Cognitive Theory	(+)
Short et al. (2014)	cross-sectional	Breast cancer survivors	N/A	(+)
Van Roie et al (2015)	Follow up to RCT	Community dwelling older adults	Self-Determination Theory	( )

(+) is indicative of a positive relationship and ( ) is indicative of no relationship

Self-Efficacy in Transtheoretical Model of Behavior Change

As seen in Table 1, self-efficacy was assessed in five studies utilizing the Transtheoretical model of behavior change. Three studies showed positive relationships with self-efficacy and resistance training. Fetherman, Hakim, and Sanko (2011) sought to determine if the application of a Transtheoretical Model intervention influenced behavior change in older women. They conducted a quasi-experimental pre-posttest design with a strength training only group and a strength training + behavior change group. Strength training + behavior change participants received counseling sessions. Self-efficacy was assessed as a sum score of five-items, each on a seven-point Likert scale. One major issue with this survey was that 0 on the scale represented "does not apply to me", a distinctly different group of categorical responses as compared to "not at all confident =1" "somewhat confident=4" and "very confident=7". This scale also measured exercise, not resistance training specifically. Participants in this study likely opted for the 0 option as on posttest for the strength training only group the average score was 14.11 with a standard deviation of 9.80, meaning on the low end of one standard deviation scores may have been 4.31, which is less than the lowest score of 1 for each question. At the end of the study self-efficacy was not different between groups, although this may have been a function of the small sample size (n=27). There was a difference in stage of change between the groups. This study did not directly test self-efficacy as a predictor of stage of change (Fetherman, Hakim & Sanko, 2011).

Ott et al. (2004) examined self-efficacy's relationship to adherence and progressive use of heavier weights in twenty-three breast cancer survivors. All women in this study were in the preparation phase. Exercise instructors coached the women in this study during two home visits

one week apart. Research nurses also provided TTM facilitative strategies based on the participants needs (i.e. low self-efficacy, low use of processes of change). For example, research nurses would provide strategies to enhance self-efficacy for individuals who reported low self-efficacy. Self-efficacy items probed two different categories, including belief in knowledge and ability to perform strength training as well as the extent to which participants believed they would do strength training despite difficulties that may arise. Although two categories were measured, there was no discrimination between the two subfunctions of self-efficacy. Throughout the study, self-efficacy levels did not significantly increase. Scores were relatively high at the beginning of the program (4.03 SD=0.74 on a five-point scale) and did not change at 2-month and 6-month follow ups. There were no significant relationships between self-efficacy and adherence, or weight lifted at 6 months.

All three studies showing positive associations using the Transtheoretical Model were cross-sectional in design. Cardinal and Kosma (2004) observed that self-efficacy was a significant correlate of the stages of change for strength training behavior in college students (Cardinal & Kosma, 2004). Stage of change differences in self-efficacy were observed with those in precontemplation reporting the lowest values and those in maintenance reporting the highest values. Cardinal, Keis and Ferrand (2005) also observed that self-efficacy was a predictor of stage of change. Once again, participants in the precontemplation stage reported the lowest self-efficacy values and those in maintenance reported the highest values. The primary difference in self-efficacy was between maintenance and the other stages of change (Cardinal, Keis, & Ferrand, 2005). Harada et al. (2008) found that participants at later stages of change tended to have higher self-efficacy. The association between self-efficacy and stage of change

tended to be stronger with later stages with the exception of the relationship between contemplation and preparation (Harada et al., 2008).

In the Transtheoretical Model, self-efficacy is a psychological variable that may affect the transition of the stages of change. Three of the studies with positive associations showed that in advanced stages participants tended to have higher self-efficacy. Individuals who have achieved maintenance tend to have significantly higher levels of self-efficacy. However, all three studies asked participants about their confidence to overcome barriers and did not assess confidence in skill levels of resistance training. Furthermore, cross-sectional designs only show correlation not causation, therefore, it is unknown if enhancing self-efficacy would result in individuals moving into higher levels of stage of change.

Self-Efficacy in Social Cognitive Theory

All five studies that used a Social Cognitive Theory or Self-Efficacy Theory framework found positive associations with resistance training (as seen in Table 1). In the only correlational study Rhodes, Williams and Mistry (2016) sough to disentangle self-efficacy from motivation using a construct called perceived capability. With a small effect size, perceived capability was correlated with intention and resistance training behavior. Perceived capability was a significant predictor of behavior ($\beta = .13$) (Rhodes, Williams, & Mistry, 2016).

Gao, Xiang, Lee, and Harrison (2008) and Gao, Hannon, and Yi (2007) examined self-efficacy in college students using a longitudinal design. Gao, Xiang, Lee, and Harrison (2008) sought to understand the relationship between self-efficacy and outcome expectancy for novices engaging in resistance training as a part of college course. At the outset of the program self-efficacy did not predict any variance in behavioral intentions but did predict variance in behavior. At the midpoint of the program, self-efficacy predicted behavioral intention and accounted for 16.50% of the variance in behavior (Gao, Xiang, Lee, & Harrison, 2008). Gao,

Hannon, and Yi (2007) also found that self-efficacy was a significant predictor of behavioral intention and a small but significant predictor of behavior (Gao, Hannon, and Yi, 2007).

In a quasi-experimental study Neupert, Lachman, and Whitbourne (2009) examined exercise self-efficacy during and after a strength training intervention in older adults. Participants engaged in resistance training with Therabands with the assistance of a 35-minute training video. Participants also received three home visits from a physical therapist. In the experiment, a therapist used cognitive strategies to enhance beliefs related to exercise and employed bimonthly phone calls to monitor participant progress. It was found that participants with higher beliefs at 6 months were more likely to be involved in the program at 9 and 12 months. However, the authors in this study measured self-efficacy on a 4-point scale with 1 representing very sure and 4 representing not at all sure. They used a mean score and stated that higher scores indicated greater self-efficacy which is contradictory to the scale that they used where lower scores would be indicative of higher self-efficacy (Neupert, Lachman, & Whitbourne 2009).

Lubans and colleagues (2012) studied mediators of resistance training behavior change in obese type II diabetics. The intervention targeted task, scheduling, and barrier self-efficacy along with several other constructs including outcome expectations, intention, planning, and social support. The mediated effects from task, scheduling, and barrier self-efficacy approached significance. However, none of the self-efficacy variables were mediators. Changes in task and barrier self-efficacy and were also associated with changes in resistance training behavior. Millen and Bray (2009) aimed to improve self-efficacy in cardiac rehabilitation patients. Participants in the intervention group showed significantly higher scores compared to the control group for adherence self-efficacy. However, self-efficacy did not improve significantly as a

result of the intervention. Self-efficacy partially mediated the effects of the intervention onto resistance training behavior (Millen and Bray, 2009).

Both RCT studies were unable to significantly improve self-efficacy. Lubans et al. (2012) targeted task self-efficacy by having personal trainers demonstrate correct technique. Scheduling self-efficacy was targeted by prompting self-monitoring of behavior. Participants were also encouraged to schedule their resistance training sessions. Barrier self-efficacy was addressed by having participants identify barriers and come up with strategies to overcome the barriers. Millen and Bray (2009) targeted self-efficacy through an instructional manual that showed successful performance of exercises and through a goal-directed progression of resistance over time. The manual had included images of similar other performing resistance training. To target verbal persuasion, the manual provided encouraging statements and an endorsement by a cardiac physiology and rehabilitation researcher (Millen & Bray, 2009). Within Social Cognitive theory, cross-sectional and longitudinal studies show that self-efficacy is positively associated with resistance training behavior, however, no study has successfully enhanced self-efficacy. Therefore, while correlational or longitudinal relations do exist, it is unknown if enhancing self-efficacy would contribute to increased participation.

Self-Efficacy in Protection Motivation Theory
Only one longitudinal study utilized Protection Motivation Theory. Plotnikoff et al. (2009) asked type II diabetics about their confidence to overcome barriers to resistance training. There were significant associations between self-efficacy and resistance training behavior and intention. The specific type of self-efficacy that was measured by Plotnikoff et al. (2009) could be described as barrier self-efficacy. Barrier self-efficacy was significantly associated with intentions and behavior. Self-efficacy and age contributed to 20% of the variance in behavior.

Self-Efficacy in Self-Determination Theory

Only one study utilized Self-Determination Theory. Van Roie, and colleagues (2015) examined data from a 24 week follow up from a 12-week resistance training RCT in older adults. Self-efficacy scales probed participants for their confidence to overcome barriers. Self-efficacy did not contribute to long term adherence (Van Roie, Bautmans, Coudyzer, Boen, & Delecluse 2015). This study had electronic records of attendance at fitness centers which is one of the only studies that utilized objective measures. Adherence rates were low in this study postintervention. Similar to the other RCT's it is worthwhile to note that self-efficacy did not change for either group in the study nor did self-efficacy contribute to long term adherence. This is despite adults being moderately to highly confident that they could do resistance exercise when confronted with barriers.

Self-Efficacy in Integrated Theories

One cross-sectional study (Patterson et al., 2015) and two longitudinal studies (Gao & Kosma, 2008; Paech & Lippke, 2017) utilized integrated models. Patterson et al. (2015) used the integrated behavior change model, Gao and Kosma (2008) integrated the Theory of Planned Behavior with Self-efficacy Theory and Paech & Lippke (2017) integrated the HAPA with Self-Determination Theory. Patterson et al. (2015) found that self-efficacy was the strongest correlate of meeting the strength training guidelines (Patterson, Umstattd Meyer, & Beville, 2015). Gao and Kosma (2008) found that self-efficacy directly predicted intention and behavior with small indirect effects on behavior through intention. Paech and Lippke (2017) followed orthopedic outpatients for seven years to understand the relationship between resistance training adherence and psychosocial variables. It was observed that the duration of strength training dramatically decreased. At 1-year follow-up action planning was predicted by self-efficacy and action

planning predicted strength training. Strength training was indirectly predicted by intention through self-efficacy. At three years the intention-self-efficacy-behavior relationship still held.

The three integrated studies observed positive associations between self-efficacy and behavior. However, two of the three studies (Paech & Lippke, 2017; Patterson et al., 2015) did not use measures that asked participants about their confidence for resistance training. Scales utilized by Gao and Kosma (2008) measured students' confidence that they could learn weight training skills and that they could attend sessions. The scales used by Patterson et al. (2015) did not reference resistance training. Paech and Lippke (2017) called their construct "maintenance self-efficacy" which focused on confidence to be physically active in the face of barriers.

Self-Efficacy Summary

Two RCT's and one follow-up to an RCT attempted to enhance self-efficacy for resistance training. None of these studies were able to demonstrate an increase in self-efficacy. The quasi-experimental studies with older adults by Neupert et al. (2009) and with breast cancer survivors by Ott et al. (2004) also did not show changes in self-efficacy. Therefore, it is unknown if improving self-efficacy has an impact on resistance training participation. All of these studies were completed with special populations, specifically, older adults, type II diabetics, and breast cancer survivors. None of the RCT's or pre-test posttest studies were done with healthy younger individuals. Each cross-sectional and longitudinal study observed positive relationships with self-efficacy and behavior. Conceptually, there are potential issues with the construct of self-efficacy due to the different ways in which researchers define and measure self-efficacy. For example, some researchers measure participants' confidence to overcome barriers whereas others ask participants about their confidence to learn resistance training or adhere to a specified number of days per week of resistance training. Because these measures may be querying participants for different concepts they should be separated in an analysis. It is also

important to determine where self-efficacy constructs would be incorporated into on a conceptual model. For example, it is not yet known if self-efficacy predicts behavioral intentions (Gao & Kosma, 2008) or behavior or mediates the intention-behavior relationship (Paech & Lippke, 2017). Or could some forms of self-efficacy predict intention (i.e. task self-efficacy) and behavior whereas others (i.e. barrier self-efficacy) mediate the intention-behavior relationship.

Perceived Behavioral Control

Perceived behavioral control (PBC) is compatible with self-efficacy. PBC describes a person's perception of the ease or difficulty of performing the behavior (Ajzen, 1991). PBC was found in 9 studies (see Table 2). The populations studied included college students (N=3), cancer survivors (N=3) older adults (N=2), diabetics (N=1). Six of the studies used the Theory of Planned Behavior as a theoretical model. Two studies used integrative frameworks and one study did not specify a theoretical background. Eight studies showed positive relationship with resistance training behavior or intention. None of the examined studies observed a negative relationship. Four studies were cross-sectional, three were longitudinal, one was quasi-experimental, and one was a RCT.

Table 2. Perceived Behavioral Control and Resistance Training

Alphabetical List of Authors	Study Design	Population	Theory	Association *
Bryan and Rocheleau (2002)	Longitudinal	College students	Theory of Planned Behavior	(+)
Courneya et al. (2004)	RCT	Cancer survivors	Theory of Planned Behavior	(+)
Dean et al. (2006)	Cross-sectional	Older adults	Theory of Planned Behavior	(+)
Forbes et al. (2015)	Cross-sectional	Cancer survivors	Theory of Planned Behavior	(+)
Jette et al. (1998)	Quasi experimental	Older adults	N/A	(+)
Patterson et al. (2015)	Cross-sectional	College students	Integrated Behavioral Model	(+)
Plotnikoff et al. (2008)	Longitudinal	Type II diabetics	Theory of Planned Behavior	( )
Rhodes et al. (2007)	Longitudinal	College students	Theory of Planned Behavior Multi-Process Action Control Framework integrated with the Theory of Planned Behavior	(+)
Vallerand et al. (2016)	Cross-sectional	Cancer survivors		(+)

(+) is indicative of a positive relationship and ( ) is indicative of no relationship

Perceived Behavioral Control in Theory of Planned Behavior

Two cross-sectional studies (Dean, Farrell, Kelley, Taylor, & Rhodes, 2006; Forbes, Blanchard, Mummery, & Courneya, 2015), three longitudinal studies (Bryan & Rocheleau, 2002, Plotnikoff, Courneya, Trinh, Karunamuni, & Sigal, 2008; Rhodes, Blanchard, & Matheson, (2007), and one RCT (Courneya et al., 2004) examined the PBC construct using the TPB. Dean et al. (2006) tested the efficacy of the TPB to explain strength-training behavior in older adults. Forbes, Blanchard, Mummery, and Courneya (2015) sought to examine correlates of strength training in breast cancer survivors. Dean and colleagues (2006) used hierarchical regression to examine the correlates of behavior whereas Forbes et al. (2015) were interested in contributing factors to meeting the strength training recommendations as well as differences between those meeting the recommendations and those not meeting the recommendations. Dean et al. (2006) found the PBC was a significant predictor of behavioral intention but not of behavior. Forbes et

al. (2015) observed that those meeting the guidelines scores higher on PBC but PBC did not predict behavior (Forbes et al., 2015). Despite using the TPB as a theoretical background, Forbes and colleagues did not examine if PBC predicted behavioral intentions. Furthermore, Forbes et al. (2015) queried participants about future PBC while past behavior was assessed ("If you were really motivated, participating in PA over the next month would be .... (PBC) and ""Have you done any strength exercises in the past month?" (behavior)., therefore the temporal sequence between PBC and behavior was incorrectly assessed.

Longitudinal studies showed mixed results and relationships with intention and behavior. Rhodes et al. (2007) observed that PBC was a significant predictor of behavior but not intention (Rhodes et al., 2007). Bryan and Rocheleau (2002) found that PBC predicted intentions and behavior. Plotnikoff et al. (2008) observed that PBC did not predict intention or behavior. In their univariate analysis Courneya et al. (2004) found that PBC was predictive of exercise adherence but when other psychosocial variables were considered it was not predictive of behavior (Courneya et al., 2004). PBC was not used as a variable to predict intention.

Only one paper (Plotnikoff et al. 2008) did not find any associations with PBC. The TPB as a theoretical model specifies some form of temporal sequence with intention predicting future behavior. Intention in turn is believed to be predicted by PBC. PBC is also posited to directly predict behavior. Cross-sectional studies do not fit into the TPB framework as intention for future behavior is assessed at the same time as past behavior. Furthermore, the relationship between PBC and behavior is thought to be mediated by intention. Only two studies tested the TPB with some form of mediation analysis (Bryan & Rocheleau, 2002; Rhodes et al., 2007). Dean et al. (2006) did use intention as its own dependent variable. In this case, PBC was a significant predictor of behavioral intention (Dean et al., 2006). Of the studies that conducted a

mediation analysis, one found that PBC predicted behavior but not intention (Rhodes et al., 2007) and the one observed that PBC predicted intention and behavior (Bryan & Rocheleau, 2002). Based on these papers it is likely that PBC contributes to behavioral intentions (Dean et al., 2006; Bryan & Rocheleau, 2002) and may also contribute to behavior (Rhodes et al., 2007).

Perceived Behavioral Control in Integrated Theories

Patterson, Umstatttd Meyer, and Beville (2015) used the Integrated Behavioral Model and Vallerand, Rhodes, Walker, and Courneya, (2016) integrated the TPB with the Multi-Process Action Control (M-PAC) framework. Both studies were cross-sectional. Similar to Dean and colleagues (2006) Vallerand et al. (2016) used intention as a dependent variable. PBC was related to intention formation (OR= 1.38). Despite using a model where PBC predicted intention, Patterson et al. (2015) did not examine intention as a dependent variable and PBC was not predictive of behavior. Both studies are limited by their design. Vallerand et al. (2016) did use intention as a dependent variable, with PBC predicting behavioral intentions. The study by Patterson et al. (2015) is limited by its statistical analysis and by the cross-sectional nature of the design.

Perceived Behavioral Control Summary

None of the examined studies attempted to enhance PBC, therefore it is not possible to determine if improving this construct would contribute to improved intentions or greater adherence to resistance training. Similar to self-efficacy, it is unknown if improving PBC does have an impact on resistance training participation. Three of the examined studies suggest that PBC predicts intentions (Bryan & Rocheleau, 2002; Dean et al., 2006; Vallerand et al., 2016) and one suggest that PBC may predict behavior (Rhodes et al., 2007). Therefore, within a conceptual model such as the TPB, PBC is an important correlate of intention.

Attitude

Attitudes describe the degree to which a person has a favorable or unfavorable appraisal of a behavior (Ajzen, 1991). More favorable attitudes and PBC contribute to stronger intentions (Ajzen, 1991). Attitude was examined in 10 studies (seen in Table 3). Attitude refers to beliefs about the expected benefits of the behavior as well as the expected affective feelings (i.e. unpleasant-pleasant). There were four cross-sectional studies, three longitudinal studies, one quasi-experimental study, one follow up to an RCT, and one RCT. The populations studied included college students (N=3), older adults (N=3), diabetics (N=1), and cancer survivors (N=3). The theoretical backgrounds used to study were the Theory of Planned Behavior (N=6), Self-Determination Theory (N=1), and two integrated theories. One study did not state a theoretical basis. Seven studies showed positive associations with intention or behavior and three studies showed no association. None of the examined studies observed a negative relationship. Attitude was assessed in a variety of ways. Bryan and Rocheleau (2002) assessed efficacy beliefs and hedonistic beliefs (Bryan and Rocheleau, 2002). Attitude was assessed as instrumental or affective by several authors (Courneya et al., 2004; Dean et al., 2006; Forbes et al., 2015; Jette et al., 1998; Plotnikoff et al., 2008; Rhodes et al., 2007; Vallerand et al., 2016). Van Roie et al. (2015) assessed feelings related to exercise. This questionnaire did ask participants about enjoyment, pride in completing strength training but also confidence and motivation, thus this item likely did not solely assess the attitude construct. Forbes et al. (2015) were the only authors to separately examine the different types of attitude (instrumental vs affective).

Table 3. Attitude and Resistance Training

Alphabetical list of Authors	Study Design	Population	Theory	Association*
Bryan and Rocheleau (2002)	longitudinal	College students	Theory of Planned Behavior	(+)
Courneya et al. (2004)	RCT	Cancer survivors	Theory of Planned Behavior	( )
Dean et al. (2006)	Cross-sectional	Older adults	Theory of Planned Behavior	( )
Forbes et al. (2015)	Cross-sectional	Cancer survivors	Theory of Planned Behavior	(+)
Jette et al. (1998)	Quasi experimental	Older adults	N/A	(+)
Patterson et al. (2015)	Cross-sectional	College students	Integrated Behavioral Model	(+)
Plotnikoff et al. (2008)	Longitudinal	Type II diabetics	Theory of Planned Behavior	(+)
Rhodes et al. (2007)	Longitudinal	College students	Theory of Planned Behavior	(+)
Vallerand et al. (2016)	Cross-sectional	Cancer survivors	Multi-Action Control Framework integrated with the Theory of Planned Behavior	(+)
Van Roie et al (2015)	Follow up to RCT	older adults	Self-Determination Theory	( )

(+) is indicative of a positive relationship and ( ) is indicative of no relationship

Attitudes in Theory of Planned Behavior

Four of the studies that utilized the TPB found positive associations with attitude on behavior or intention. Two did not find an association. Cross-sectional studies were conducted by Dean et al. (2006) and Forbes et al. (2015). Dean et al. (2006) did not observe any associations with attitude on behavior or intention (Dean et al., 2006). Forbes and colleagues observed that participants meeting the guidelines for strength straining scored higher on affective and instrumental attitudes (Forbes et al., 2015) but did not predict behavior. Despite using the

TPB as a framework where attitudes predict intentions not behavior, intention was not assessed as a dependent variable, therefore attitude was not used to predict intentions.

Three longitudinal studies used the TPB (Bryan and Rocheleau, 2002; Plotnikoff et al., 2008; Rhodes et al., 2007). Attitude was shown to have indirect effects on behavior through intention (Bryan & Rocheleau, 2002; Rhodes et al, 2007). Plotnikoff et al. (2008) found that attitude predicted intention, but intention did not predict behavior (Plotnikoff et al., 2008). Courneya et al., (2004) did not find any associations between attitude and behavior (Courneya at al., 2004).

The TPB suggests a mediation model where the effects of attitude are mediated through intention. Four of the examined studies (Courneya et al., 2004; Dean et al., 2006; Forbes et al., 2015; Plotnikoff et al., 2008) used a hierarchical regression analysis which cannot test the indirect effects of attitude via intention. Only one study (Plotnikoff et al., 2008) used intention as a dependent variable. The two studies that observed indirect effects of attitude on behavior via intention used structural equation modelling (Bryan & Rocheleau, 2002; Rhodes et al., 2007). Based on the examined studies using the TPB, attitude is a predictor of behavioral intentions (Bryan & Rocheleau, 2002; Plotnikoff et al., 2008; Rhodes et al., 2007) and likely exerts its influence on behavior via intentions (Bryan & Rocheleau, 2002; Rhodes et al., 2007). It is unknown if enhancing positive attitudes has an influence on behavioral intentions.

Attitudes in Integrated Models

Patterson et al., (2015) utilized the Integrated Behavior Change Model (IBM) and Vallerand et al. (2016) integrated the TPB with the Multi-Process Action Control Framework. Both studies were cross-sectional. Similar to the TPB, in the IBM, attitudes are predictive of intention and intention is predictive of behavior. Attitude was a significant correlate of meeting the recommendations but did not predict whether or not participants met the recommendations

(Patterson et al., 2015). Vallerand et al. (2016) assessed intention and behavior as dependent variables. Attitude was a multivariate correlate of intention formation (OR=1.56). Having a positive attitude was also a correlate of translating intentions into behavior (OR= 1.68).

The study by Patterson et al. (2015) suffered from limitations similar to that which were noted in the TPB studies. Based on the IBM, attitudes were proposed to predict intention. However, this conceptual model was not tested. Vallerand et al. (2016) tested this hypothesis and found that higher attitudes were associated with intending to meet the guidelines. Both studies were cross-sectional; therefore, causal inferences cannot be made. However, once again when intention is treated as a dependent variable, attitudes are shown to be associated.

Attitudes in Self-Determination Theory

Van Roie et al. (2015) completed a follow-up analysis to an RCT. The authors assessed feelings related to exercise. Some of the items assessed attitudes (i.e. how much did you enjoy the strengthening exercises; how proud are you that you were able to complete these strengthening exercises) along with questions about motivation and confidence. Feelings related to exercise did not predict long-term adherence to strength training (Van Roie et al., 2015). Feelings related to exercise likely examined more than one construct, not just attitude. Because of the multidimensional nature of the feelings construct this study adds little to the narrative on attitude.

Attitude Summary

None of the examined studies attempted to modify the attitude construct. Therefore, it is unknown if changing attitude for resistance training changes behavior. Attitude was most commonly assessed as instrumental and affective although only one study examined the distinct differences between the two types of attitude on any outcome. Forbes et al. (2015) found that participants who were meeting the guidelines scored higher on instrumental but not affective

attitudes (Forbes et al. 2015). The function of these two types of attitude may be different based on the population being assessed. For example, cancer survivors may realize the importance of resistance training on their health (instrumental attitude) and may therefore, participate in resistance training even if they do not hold positive affective attitudes. Attitude only directly predicted exercise adherence in one study by Jette et al., (1998). This study did not propose a theoretical framework (Jette et al., 1998). Five of the studies that used the TPB or some type of TPB model (IBM) did not test whether attitudes predicted intention. When attitude was analyzed using the appropriate TPB conceptual model, attitude was shown to be predictive of behavioral intentions. Therefore, attitudes towards resistance training are likely predictive of intending to do resistance training with intention mediating the effects of attitudes onto behavior.

Outcome Expectations
        Outcome expectations describe the outcomes people expect their behavior to produce. Outcome expectations may include physical outcomes, social approval outcomes, and positive or negative self-evaluations to one's health behavior (Bandura, 2004). Outcome expectations were examined in 12 studies (Table 4). Expected outcomes were assessed as decisional balance (Cardinal et al, 2005; Fetherman et al., 2011; Ott et al., 2004), as incentive which is the multiplicative value of outcome expectations and outcome value (Gao & Kosma, 2008; Gao et al, 2007; Gao et al., 2008), response efficacy (Plotnikoff et al., 2009), and as outcome expectations which encompassed weighing the pros (Millen & Bray, 2009) and pros and cons of resistance training (Lubans et al., 2012; Short et al., 2014; Williams et al., 2015; Williams et al., 2016).

        There were three cross-sectional studies, five longitudinal studies, one quasi-experimental study, one pretest-posttest study, and three RCT. The populations studied included college students (N=4), older adults (N=2), diabetics (N=2), prediabetics (N=1), cardiac patients

(N=1) and cancer survivors (N=2). The theoretical backgrounds used to study were Social

Cognitive Theory or Self-efficacy Theory (N=6), the Transtheoretical Model (N=3), and

Protection Motivation Theory (N=1). There was one integrated theoretical framework and one

study did not state a theoretical background. Eight studies showed positive associations with

intention or behavior and four studies showed no association. None of the examined studies

observed a negative relationship.

Table 4. Outcome Expectations and Resistance Training

Alphabetical List of Authors	Study Design	Population	Theory	Association *
Cardinal et al. (2005)	Cross-sectional	College students	Transtheoretical Model	(+)
Fetherman et al. (2011)	Quasi experimental	Older women	Transtheoretical Model	(+)
Gao & Kosma (2008)	Longitudinal	College students	"Self-efficacy Theory integrated with Theory of Planned Behavior"	(+)
Gao et al. (2007)	Longitudinal	College students	Self-efficacy Theory	(+)
Gao et al. (2008)	Longitudinal	College students	Self-efficacy theory	(+)
Lubans et al. (2012)	RCT	Type II diabetics	Social Cognitive Theory	( )
Millen & Bray (2009)	RCT	Cardiac patients	Social Cognitive theory	( )
Ott et al. (2004)	One group pretest-posttest	Breast cancer survivors	Transtheoretical Model	( )
Plotnikoff et al. (2009)	Longitudinal	Type II diabetics	Protection Motivation Theory	(+)
Short et al. (2014)	cross-sectional	Breast cancer survivors	N/A	(+)
Williams et al. (2015)	Longitudinal	Older adults	Social Cognitive Theory	(+)
Williams et al. (2016)	RCT	Prediabetic adults	Social Cognitive Theory	( )

(+) is indicative of a positive relationship and ( ) is indicative of no relationship

Outcome Expectations in Social Cognitive Theory

Three longitudinal studies and three RCTs assessed outcome expectations using Social Cognitive Theory. The three longitudinal studies found positive associations with outcome expectations and behavior or intention and the three RCTs found no association with outcome expectations and behavior or intention. Williams and colleagues (2015) developed a questionnaire for outcome expectations. The questionnaire was reduced to 16 items weighing the pros and cons of resistance training. Positive and negative outcome expectancy scores had moderate associations with follow-up resistance training (r = .326 to .460). Gao, Hannon, and Yi (2007) measured the value of three types of outcome expectations including physical, social, and self-evaluative in a beginner weight training class. Physical outcome expectations were a significant predictor of behavioral intention and behavior (Gao, Hannon, & Yi, 2007). Gao, Xiang, and Lee (2008) examined the effects of outcome expectations at different time periods in a beginning weight training class. The same scale at the Gao et al., (2007) was used. Outcome expectancy was a significant predictor of behavioral intention and behavior at the beginning of the program. At the midpoint of the program outcome expectations no longer predicted intentions or behavior (Gao, Xiang, & Lee, 2008).

Williams and colleagues (2016) examined the mediators of resistance training in a high vs low dose behavior change RCT. Both the low dose and high dose received the same information to enhance outcome expectations. There were no significant changes in outcome expectations and outcome expectations were not related to behavior (Williams, Dunsiger, Davy, Kelleher, Marinik, Winett, 2016). Lubans, Plotnikoff, Jung, Eves, and Sigal (2012) targeted outcome expectations by providing information about the health behavior link and the consequences of physical inactivity to resistance training. The intervention did not have an impact outcome expectations. Millen and Bray (2009) studied the transition from structured

resistance training to home-based activity for cardiac rehabilitation patients. Outcome expectations were targeted by informing patients about what they should be able to do after participation in resistance training. Differences in outcome expectations between groups approached significance in favor of the experimental group. However, there were no significant changes from pretest to post test and outcome expectations did not predict behavior (Millen & Bray, 2009).

The longitudinal study by Williams et al. (2015) examined correlations between behavior and outcome expectations. The relationship was significant; however, the predictive nature of outcome expectations on behavior was not explored as the purpose of this study was measure development. The two studies by Gao and colleagues (2007, 2008) observed positive longitudinal associations between outcome expectations, intentions, and behavior. Physical outcome expectations were predictive of intention and behavior (Gao et al., 2007). When outcome expectations were measured at different time points along with self-efficacy the effects of outcome expectations were significant before participants gained experience but once experience was gained self-efficacy emerged as the only significant predictor of behavior and intentions (Gao et al., 2008). Both studies by Gao and colleagues (2007, 2008) were done for course credit. Thus, a sense of obligation to pass the course may have contributed to behavior. The RCT's did not observe any malleability of the outcome expectation construct nor were any associations observed with behavior. Williams et al. (2015) did observe small positive and significant correlations with behavioral intentions and positive outcome incentives (value x outcome expectancy). However, no significant correlations were observed with behavior (Williams et al., 2015).

Outcome Expectations in the Transtheoretical Model of Behavior Change

Outcome expectations were examined as decisional balance in papers that used the Transtheoretical Model of Behavior Change. Decisional balance was assessed in one cross-sectional study and two pretest-posttest studies. Cardinal, Keis, and Ferrand (2005) observed that perceived pros and cons both contributed to stage of change classification. Stage- of-change differences were observed for the pros with those in precontemplation reporting the lowest values and those in maintenance reporting the highest values (Cardinal, Keis, & Ferrand, 2005). Fetherman, Hakim, and Sanko (2011) successfully increased the pros and reduced the cons of exercise for an intervention group. There were significant differences between groups for pros with the intervention group reporting more pros. At the end of the study the intervention group members were in later stages of change compared to the strength training only group (Fetherman, Hakim, & Sanko, 2011). Ott et al. (2004) also successfully increased the total pros of strength training. However, there were no associations between decisional balance and adherence (Ott et al., 2004).

Individuals in the later stages of change may score higher on the perceived pros of resistance training compared to those in earlier stages. Individuals may move to later stages of change when the pros of resistance training increase and the cons decrease. However, based on the analysis by Fetherman et al. (2011) it is not possible to determine if changes in decisional balance contribute to changes in stage of change. Ott et al. (2004) successfully enhanced the pros of strength training but this was unrelated to stage of change. Therefore, research suggest that decisional balance is a malleable construct but changing this construct does not necessarily change behavior.

Outcome Expectations in Protection Motivation Theory

In a longitudinal study, Plotnikoff et al. (2009) measured outcome expectations as response efficacy. Response efficacy is the individual's expectancy that implementing resistance training can remove a health threat. Response efficacy was significantly associated with intentions but not behavior (Plotnikoff et al., 2009). This study adds evidence that expected outcomes are more predictive of intentions than of behavior.

Outcome Expectations in Integrated Theories

Gao and Kosma (2008) integrated the TPB with Self-Efficacy Theory. Outcome expectations were measured as incentive. Incentive directly predicted behavioral intentions and intentions predicted behavior. Indirect effects of incentive through intention on behavior were small (Gao & Kosma, 2008). Once again, this study adds evidence that expected outcomes contribute to intentions to engage in resistance training.

Outcome Expectations Summary

Gao and colleagues (2007, 2008, 2008) conducted three longitudinal studies that examined outcome expectations. Each of these studies showed that outcome expectations had relationships with behavioral intentions. At the beginning of a strength training program, outcome expectations were predictive of behavior and of intentions (Gao, Xiang, & Lee, 2008). Plotnikoff et al. (2009) also observed longitudinal associations with expected outcomes and behavioral intentions. Scores on perceived pros of resistance training were significantly higher for participants in maintenance compared to those who had no intention to do resistance training (Cardinal et al., 2005).

None of the studies using Social Cognitive Theory were able to change outcome expectations. This contrasts with the two experimental studies using the Transtheoretical Model that were able to enhance the pros of exercise (Fetherman et al., 2011; Ott et al., 2004). However, these two studies failed to examine if enhancing the pros of exercise or reducing the

cons of exercise contribute to changes in stage of change. Outcome expectations were measured in a variety of ways depending on the theory in use. Overall, outcome expectations were ostensibly measured in four different ways including outcome expectations, incentive, decisional balance, and response efficacy. These differences make comparisons challenging across studies. Furthermore, the outcome expectation construct is comparable to the instrumental attitude construct. Like attitudes, outcome expectations are a construct that contribute to intention formation. However, it is unknown if enhancing outcome expectations increases intentions or behavior.

Intention

Intentions are an indication of how much effort a person is willing to exert in order to engage in a behavior. Intentions describe all the motivational factors that influence behavior (Ajzen, 1991). A behavioral intention or goal intention represents the end of the deliberation process. It symbolizes one's commitment to action (Sheeran, Milne, Webb & Gollwitzer, 2005). Intention was examined in 13 studies (Table 5). The populations studied included college students (N=4), diabetics (N=3), cancer survivors (N=3), older adults (N=1), orthopedic outpatients (N=1), and prediabetics (N=1). The theoretical backgrounds used to study intention included the TPB (N=6), Social Cognitive Theory (N=2), integrated models (N=4) which included the integration of Self-efficacy Theory with the TPB, the Health Action Process Approach integrated with Self-Determination Theory, the Multi-Process Action Control Framework with the TPB, and the Integrated Behavior Change Model. Protection Motivation Theory (N=1) was used in one study. Intention was examined in four cross-sectional studies, six longitudinal studies, and three RCTs. Ten studies showed positive relationships with resistance training and three showed no relationship. None of the studies observed a negative relationship. Intention is a construct that is often used as a dependent variable as well as a predictor variable

of behavior. Therefore, it is worth examining what contributes to intention as well as the extent

to which intention contributes to behavior.

Table 5. Intention and Resistance Training

Alphabetical List of Authors	Study Design	Population	Theory	Association *
Paech & Lippke (2017)	Longitudinal	Orthopedic outpatients	Health Action Process Approach integrated with Self-Determination Theory	(+)
Patterson et al. (2015)	Cross-sectional	College students	Integrated Behavior Change Model	(+)
Vallerand et al. (2016)	Cross-sectional	Cancer survivors	Multi-Process Action Control Framework Theory of Planned Behavior	(+)
Plotnikoff et al. (2009)	Longitudinal	Type II diabetics	Protection motivation theory	( )
Williams et al. (2016)	RCT	Overweight prediabetic adults	Social cognitive framework	(+)
Lubans et al. (2012)	RCT	Type II diabetics	Social Cognitive Theory	( )
Bryan and Rocheleau (2002)	longitudinal	College students	Theory of Planned Behavior	(+)
Courneya et al. (2004)	RCT	Cancer survivors	Theory of Planned Behavior	(+)
Dean et al. (2006)	Cross-sectional	Older adults	Theory of Planned Behavior	(+)
Forbes et al. (2015)	Cross-sectional	Cancer survivors	Theory of Planned Behavior	(+)
Plotnikoff et al. (2008)	Longitudinal	Type II diabetics	Theory of Planned Behavior	( )
Rhodes et al. (2007)	Longitudinal	College students	Theory of Planned Behavior	(+)
Gao & Kosma (2008)	longitudinal	College students	Theory of Planned Behavior with Self-Efficacy Theory	(+)

(+) is indicative of a positive relationship and ( ) is indicative of no relationship

Intention in the Theory of Planned Behavior

Dean et al. (2006) and Forbes et al. (2015) examined intention in cross-sectional designs.

Both studies showed positive associations with behavior (Dean et al., 2006; Forbes et al., 2015).

Conceptually, cross-sectional designs that assess future intentions along with past behavior are flawed. It is more useful to examined which constructs contribute to intention in cross-sectional studies. Dean et al. (2006) observed that PBC and subjective norms were significant predictors of behavioral intentions (Dean et al., 2006). Predictors of intention were not examined by Forbes et al. (2015). Two longitudinal studies using the TPB were done with college students (Bryan & Rocheleau, 2002; Rhodes et al., 2007). Bryan and Rocheleau (2002) observed that intentions predicted behavior and that intentions were predicted by attitudes, subjective norms, and PBC. Rhodes et al. (2007) observed similar results with attitudes and subjective norms but not PBC predicting intentions with intentions also predicting behavior (Rhodes et al., 2007). Plotnikoff et al. (2008) observed that attitudes and descriptive norms were associated with intentions, but intention did not predict behavior (Plotnikoff et al., 2008). Courneya et al. (2004) examined intention in an RCT. Intention was a marginally significant predictor of adherence. Intention was not assessed as a dependent variable (Courneya et al., 2004).

The Theory of Planned Behavior specifies a mediation model where intentions predict behavior and intentions are predicted by PBC, attitude, and subjective norms. For studies to follow this theory some type of mediation analysis must be conducted or a multiple regression with intention as a dependent variable must be conducted. Bryan and Rocheleau (2002) and Rhodes et al. (2007) were the only two studies to test the assumptions made by the TPB. Dean et al. (2006) did use intention as a dependent variable. The studies by Forbes et al. (2015), Plotnikoff et al., (2008), and Courneya (2008) did not test this assumption. Based on the three studies that tested the TPB, the antecedents of intention included PBC (Dean et al., 2006; Bryan & Rocheleau, 2002), attitudes (Bryan & Rocheleau, 2002; Rhodes et al., 2007) and norms (Dean

et al., 2006; Rhodes et al., 2007). Three of the four non-cross-sectional studies showed positive

associations with intention and behavior.

Intention in Social Cognitive Theory

Two RCT's examined intention using Social Cognitive Theory. Lubans et al. (2012)

randomized participants to a training group and a non-training control group. Participants were

asked and encouraged to plan their resistance training sessions and set goals. The intervention

did not have an impact on intentions and there were no associations with intentions and behavior

(Lubans et al., 2012). It is questionable as to whether Lubans et al. (2012) targeted intention or a

post-intentional construct of self-regulation via planning and goal setting. Conceptually, a person

must have an intention for a plan to be carried out. Williams et al. (2016) believed intention

could be enhanced via downstream effects of enhancing other constructs. However, there were

no intervention effects on intention. Those who did have more positive changes in intention did

report greater resistance training frequency. Intention did not mediate the effects of the

intervention onto behavior (Williams et al., 2016). Both RCT's failed to significantly enhance

behavioral intentions.

Intention in Integrated Theories

Two cross-sectional studies and two longitudinal studies measured behavioral intentions.

Vallerand et al. (2016) observed 51% of participants who had an intention to do resistance

training did resistance training. Of those who met the guidelines 94% had an intention to do and

6% did not. Having a favorable attitude, descriptive norm and injunctive norm scores, and PBC

were predictive of having an intention (Vallerand et al., 2016). Patterson, Umstatttd Meyer, and

Beville (2015) also observed that having an intention was predictive of meeting the guidelines.

Due to the cross-sectional nature of the study it is more accurate to say that participants who

meet the strength training guidelines have stronger intentions to do so in the future. Gao and

Kosma (2008) found that intentions were predicted by self-efficacy and incentive and that intention predicted behavior (Gao & Kosma, 2008). Paech and Lippke (2017) observed that intention indirectly predicted behavior through action plans and self-efficacy.

Intention in Protection Motivation Theory

Plotnikoff et al. (2009) observed that intentions did not predict behavior but that intentions were predicted by response efficacy and by self-efficacy. Self-efficacy was assessed as confidence to overcome barriers and response efficacy was assessed as the anticipation that resistance training would remove a health threat. Response efficacy is similar to outcome expectations. It would seem that similar to the study by Gao and Kosma (2008), expected outcome contribute to intention.

Intention Summary

Intention is a construct that has positive associations with behavior. Motivational constructs such as attitude, outcome expectations, PBC, and self-efficacy have been shown to contribute to intention formation. This is in accordance with models such as the TPB where intentions are predicted by a person's evaluation of the behavior and their confidence to execute the behavior. Individuals who engage in resistance training do so with intentions, but intentions do not guarantee that behavior will occur (Plotnikoff et al., 2009; Vallerand et al., 2016). Self-regulation strategies may help individuals act on their good intentions (Paech & Lippke, 2017; Vallerand et al., 2016)

Self-Regulation

Self-regulation provides the basis for purposeful action (Bandura, 1991). Subfunctions of self-regulation include self-monitoring of behavior, which includes the conditions under which behavior occurs and the effects of the behavior. Other subfunctions include self-observation provides information for realistic goal setting and evaluation of progress. Goal setting and planning are two other features of self-regulation. Self-regulation encompasses the goals people

set for themselves and the plans and strategies for realizing them, and the modification of facilitators and barriers to achieve the changes people seek to make (Bandura, 1991, 2004).

Self-regulation was examined in seven studies (Table 6). Self-regulation was assessed through planning (Forbes et al., 2015; Lubans et al., 2012; Paech & Lippke, 2017; Vallerand et al., 2016), specific strategies (i.e. pack ahead of time for the gym, schedule resistance training into each day) (Williams et al., 2015; Williams et al., 2015), and goal setting (Short et al., 2014).

There were three cross-sectional studies, two longitudinal studies, and two RCTs. The populations studied included cancer survivors (N=3), type II diabetics (N=1), prediabetics (N=1), orthopedic outpatients (N=1), and older adults (N=1). The theoretical backgrounds used to study were Social Cognitive Theory (N=4), the Theory of Planned Behavior (N=1), and two integrated theories. All seven studies showed positive associations with behavior. However, three of the studies (Paech & Lippke, 2017; Short et al., 2014; Vallerand et al., 2016) did not specify the use of resistance training in their measures.

Table 6. Self-Regulation and Resistance Training

Alphabetical List of Authors	Study Design	Population	Theory	Association*
Forbes et al. (2015)	Cross-sectional	Cancer survivors	Theory of Planned Behavior	(+)
Lubans et al. (2012)	RCT	Type II diabetics	Social Cognitive Theory	(+)
Paech & Lippke (2017)	Longitudinal	Orthopedic outpatients	Health Action Process Approach Self-Determination Theory	(+)
Short et al. (2014)	Cross-sectional	Cancer survivors	Social Cognitive Theory	(+)
Vallerand et al. (2016)	cross-sectional	Cancer survivors	Multi-Process Action Control Framework integrated with the Theory of Planned Behavior	(+)
Williams et al. (2015)	Longitudinal	Older adults	Social Cognitive Theory	(+)
Williams et al. (2016)	RCT	Prediabetic adults	Social Cognitive Theory	(+)

(+) is indicative of a positive relationship and ( ) is indicative of no relationship

Self-Regulation in Social Cognitive Theory

In a cross-sectional study Short et al. (2014) assessed resistance training goal setting in breast cancer survivors. Breast cancer survivors who were meeting the guidelines had higher scores on goal setting than those who did not meet the guidelines. The measured social-cognitive variables explained 17% of the variance in meeting the guidelines with task self-efficacy and goal setting emerging as significant predictors. One unit increases in goal setting results in 20% greater odds of meeting the guidelines (Short et al., 2014). In a longitudinal study, Williams et al. (2015) developed a questionnaire for self-regulation. The scale consisted of the following items; schedule resistance training into each day, make resistance training a priority, train on the same days each week, make resistance training a habit, and pack ahead of time for the gym. Self-regulation scores showed moderate associations with resistance training behavior. The purpose

of this paper was measure development, not predictive validity of self-regulation (Williams et al., 2015).

Lubans et al. (2012) and Williams et al. (2016) both assessed self-regulation in secondary analysis to RCTs. Lubans et al. (2012) encouraged participants to plan resistance training sessions and self-monitor behavior. Participants identified barriers and made plans to overcome barriers. Participants in the intervention group significantly increased planning strategies. Changes in planning showed positive associations with changes in behavior and changes in behavior were mediated by changes in planning. Williams et al. (2016) randomized participants into high and low dose behavior change conditions. High dose participants were able to choose from an online selection of strategies to overcome barriers. Participants in both conditions planned and scheduled workouts online. Participants in the high dose condition showed more positive changes in self-regulation than those in the low dose condition. Changes in self-regulation were associated with changes in behavior and mediated the effects of the intervention (Williams et al., 2016).

Individuals who set goals are more likely to be meeting strength training recommendations and moderate longitudinal associations with behavior are observed with self-regulation and behavior (Williams et al., 2015; Short et al., 2014). Importantly, self-regulation strategies such as planning are malleable constructs. Changes in self-regulation are associated with changes in behavior and mediated the effects of interventions (Lubans et al., 2012; Williams et al., 2016). Self-regulation also has positive correlations with behavioral intention (Williams et al., 2016). Helping individuals plan when and where they will do resistance training as well as helping participants plan how they will overcome barriers to resistance training is an appealing behavior change technique due to the construct's malleability and direct influence on behavior.

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Self-Regulation in the Theory of Planned Behavior

Only one cross-sectional study (Forbes et al., 2015) was conducted using the TPB. Planning was assessed with six items which asked participants if they had plans for when, where and the type of physical activity they would do in the next month. Participants who were meeting the guidelines had higher scores for planning than those not meeting the guidelines. Intentions but not planning were predictive of meeting the guidelines. The variance explained by all predictor variables was only 15%. This survey failed to ask participants about resistance training participation, rather participants were asked about physical activity (Forbes et al., 2015).

Self-Regulation in Integrated Theories

Paech and Lippke (2017) integrated the HAPA with Self- Determination Theory in a longitudinal study and Vallerand et al. (2016) integrated the M-PAC Framework with the TPB. Vallerand et al. (2016) assessed intention formation and translation. Having a detailed plan was associated with translating intentions into behavior (Vallerand et al., 2016; OR=1.86). Paech and Lippke (2017) studied action planning and behavior in orthopedic outpatients. Intentions and self-efficacy predicted action planning and action planning predicted strength training. The indirect effects of intention through action planning were significant (Paech & Lippke, 2017). Neither of these studies measured resistance training specifically. Instead they measured physical activity or exercise. However, both studies suggest that action planning is predicted by intentions and aids with translating intentions into behavior.

Self-Regulation Summary

Changes in self-regulation contribute to changes in behavior. Two RCTs have shown that self-regulation is a malleable construct (Lubans et al., 2012; Williams et al., 2016). Cross-sectional research shows that individuals who do more resistance training and achieve the guidelines use more self-regulatory strategies than those who do not (Forbes et al., 2015; Short et al., 2014). Planning, a specific self-regulatory strategy is predicted by intentions (Paech &

Lippke, 2017) and is associated with translating intentions into behavior (Vallerand et al., 2016).

Planning, due to its ability to be enhanced and due to its proximal relationship with behavior may

be an avenue to promote behavior change for resistance training.

Advancing Behavioral Research in Resistance Training

For the purposes of the proposed research several areas of the existing literature were

examined. **These areas include: First, an examination of the constructs related to behavior**

that should therefore be targeted. Evidence suggest that the psychological correlates of

resistance training behavior are self-efficacy, affective attitudes, intention, and self-regulation

(Rhodes et al., 2017). **Second, an examination of which BCT's are useful for enhancing these**

constructs. This necessitates having knowledge of all the intervention components that may

have contributed to changing the construct. Third, an examination of **under which conditions a**

specific behavior change technique was effective. Lastly, it is important to know which

constructs when enhanced will have an impact on behavior. For example, perhaps enhancing

self-regulation has a greater impact on behavior than enhancing affective attitude, despite both

being related to behavior.

Enhancing Psychological Constructs in Resistance Training Interventions

Six original RT studies (Table 7) attempted to target specific psychological constructs.

Eight papers were examined in total, two of the papers were secondary analysis focusing on

mediators. Self-efficacy and behavioral expectations, self-regulation, and outcome expectations

were the targeted constructs.

Fetherman et al. (2011) compared a strength training only group to a strength training

plus behavior change group. A Transtheoretical Model of Behavior Change goal-setting

worksheet was used for the behavior change intervention group to guide goal setting. The

worksheet incorporated strategies including goal setting, reinforcement, self-efficacy, benefit, commitment, supportive relationships, documentation, and rewards. This sheet was used to help participants identify behavior change strategies that they could use. All participants in the behavior change group received a 10-minute counseling session. The positive aspects of *decisional balance* increased for the behavior change group and were higher than the control group at post testing. There was an increase in *self-efficacy* for the behavior change group. However, this change was not significant. Because the behavior change techniques were individualized based on needs and techniques for decisional balance and self-efficacy were not described it is not possible to know what occurred during the counseling sessions (Fetherman et al., 2011).

Lubans and colleagues (2012) reported secondary data from the 16-week Alberta Diabetes Home-based Exercise Resistance Training Study. Lubans et al. (2012) reported which constructs were targeted, how they were targeted along with the name of the behavior change technique. Participants in the intervention group significantly increased their *RT planning strategies* by identifying barriers and making plans to overcome the barriers. The intervention did not have an impact on *task-self efficacy*, *intentions*, or *outcome expectations*. To target *task self-efficacy* participants performed RT with a personal trainer who corrected participants technique and provided feedback. To target *intention*, participants were encouraged to plan their RT sessions and to set goals. Lastly to target *outcome expectations* participants were provided information on the health benefits of RT and were asked to reflect on the potential benefits. Personal trainers provided the BCT's in this study.

The primary paper (Plotnikoff et al., 2010) reports that *intentions* increased significantly and were higher compared to the control group who did not receive an intervention. There are

issues with the *intention* and *planning* constructs between the primary and secondary paper. For example, in the secondary analysis *intention* is said to be reported with **one** question on a 0 to 100 scale. Participants were asked on a scale of 0% to 100%, how likely is it that you will weigh train regularly over the next 4 months. In the primary paper *intention* was measured with **two** questions on a 0% to 100% scale. The two questions were (1) if they have plans to weight train if something should keep them from weigh training and (2) if they plan to weight train in challenging situations. When reporting *intention* scores in the primary analysis the average score for the intervention group at baseline was 2.1 for question 1 and 2.2 for question too. This is not in agreement with the 100-point scale. In the secondary analysis, these numbers are reported under a *planning* construct which was not said to be measured in the primary analysis (Lubans et al., 2012; Plotnikoff et al., 2010).

Millen & Bray (2009) targeted *self-efficacy* and *outcome expectations* in cardiovascular rehabilitation participants. Participants were given a social cognitive theory based instructional manual. The control group only received standard recommendations to exercise. The manual contained instructions for 6 upper-body exercises using elastic Thera-Bands. The manual provided easy-to-read and understand instructions, clear pictures of each exercise segment, and a goal-directed progression of increasing resistance over time. *Outcome expectations* were targeted by informing participants about what they should be able to do, in terms of activities of daily living, after participating in RT. Technique and adherence *self-efficacy* was higher in the intervention group at the end of the study. *Outcome expectation scores* approached significance, favoring the intervention group. On average, scores increased for all three variables from pretest to posttest; however, the significance of the differences within the group was not assessed (Millen & Bray, 2009).

Neupert et al. (2009) examined whether experience with a resistance training program would impact *self-efficacy*. Participants were assigned to an intervention or a wait list control. Participants in the intervention received a 35-minute videotaped program using Therabands. Participants received two home visits from a physical therapist. Participants viewed a video tape aimed at enhancing participants *efficacy* beliefs. The videotape discussed potential obstacles to exercise and reviewed the benefits of exercise. Participants also received bimonthly phone calls from the therapist. Participants were instructed to identify obstacles to exercising and to make strategies to overcome the obstacles. *Self-efficacy* did not change over the course of the study (Neupert et al., 2009).

Ott et al. (2009) recruited breast cancer survivors at risk for osteoporosis. Changes in *self-efficacy* and *decisional balance* were examined. Participants received a copy of the book and video, *Strong Women Stay Young* which emphasized correct technique. Research nurses implemented facilitative strategies based on the Transtheoretical Model of Behavior Change to enhance adherence to the program. Strategies were used to enhance constructs with low ratings. However, the specifics of the techniques were not given. *Self-efficacy* did not change from baseline to 2 months or from baseline to 6 months. There was an increase in the pros score of decisional balance from baseline to 2 months and from baseline to 6 months (Ott et al., 2009).

Williams et al. (2016) report secondary data from an RCT by Winett et al. (2015). The secondary analysis was a mediation analysis from the Resist Diabetes trial, a 15-month study. *Behavioral expectations, self-regulation,* and *outcome expectations* were targeted through in person, online, and print. Participants received ongoing encouragement to exercise 2 times/week (behavioral expectations), information on the benefits of participating in RT (outcome expectations), and access to an online platform to problem solve barriers and schedule workouts

(self-regulation). The high dose intervention was able to attenuate the natural declines in *behavioral expectation* and *self-regulation* that was seen in the low dose condition. Low dose and high dose conditions did not differ in the receiving the BCTs aimed at *outcome expectations*. No differences were seen between the groups for *outcome expectations* (Winett et al., 2015; Williams et al., 2016).

Table 7. Summary of the Effects of RT Interventions on Putative Mediators

Author	Targeted Construct	Behavior Change Technique	Change in Construct
Fetherman et al. (2011)	Outcome expectations	Asked participants about the ways physical inactivity affects their lives and the ways in which physical activity would provide benefits.	The positive aspects of decisional balance increased from pre to post testing
	Self-Efficacy	Asked participants if there were any areas, they would like to improve upon	No significant changes in self-efficacy
Plotnikoff et al. (2010) Lubans et al. (2012)	Intentions	Prompted specific goal setting Prompted intention formation	No impact
	Outcome expectations	Provide information about health-behavior link Information on consequences	No impact
	Self-efficacy	Model the behavior Graded tasks Prompt self-monitoring of behavior Barrier identification	Scheduling self-efficacy increased, no impact on task self-efficacy
	Self-regulation	Prompted self-monitoring of behaviors Barrier identification	Participants significantly increased their planning strategies
Millen & Bray (2009)	Outcome expectations	Participants were informed of what they should be able to do after participating in resistance training (lifting, carrying, and pulling objects more easily)	Differences approached significance in favor of the intervention group. Pre and posttest differences were not analyzed.
	Self-efficacy	Instructional manual provoked successful performance of exercises through guided mastery in the form of easy-to-read and understand instructions, clear pictures of each exercise segment, and a goal-directed progression of increasing resistance over time	Significantly higher scores in the intervention group compared to the control group. However, pre and posttest differences were not analyzed
Neupert et al. (2009)	Self-efficacy	Participants received two home visits 1 week apart emphasizing correct form and safety. A template was designed for coaching specific strategies for rating of low self-efficacy	Self-efficacy did not change
Ott et al. (2004)	Outcome expectations	Self-reevaluation	Increased pros from baseline to 2 months and from baseline to 6 months.
	Self-efficacy	Emphasis of correct technique	No change in self-efficacy from baseline to 2 months or from baseline to 6 months
Winett et al. (2015) Williams et al. (2016)	Behavioral expectations	Ongoing encouragement to exercise two times per week.	The intervention attenuated the reductions seen in the low dose-condition
	Outcome expectations	Provided information on the positive affective and health related benefits of RT.	No significant differences between low dose condition and high dose condition.
	Self-regulation	Online problem-solving barriers and strategies approach. Participants received an online selection of strategies to overcome barriers. Participants planned and scheduled workouts.	The intervention attenuated the reductions seen in the low dose-condition.

Summary

Self-efficacy and behavioral expectations, self-regulation, and outcome expectations were the targeted constructs. There is no evidence that an intervention has had positive impacts on self-efficacy. However, interventions have had positive impacts on behavioral expectations, self-regulation, and outcome expectations. A common approach to enhance self-regulation was barrier identification. Naturally, outcome expectations were targeted by providing information related to future benefits. Next, **it is important to understand why an intervention worked**. It is equally important to know the conditions under which an intervention did not work.

Using the TIDieR Framework Check List

To replicate and build upon interventions published papers must have a complete description of the intervention (Hoffman et al., 2014). **Resistance training studies that attempt to change behavior through purported mediators must report in detail both the way in which the RT program was designed and the ways in which the behavior change intervention was implemented.** The Consolidated Standards of Reporting Trials (CONSORT) 2010 suggests that authors report details to allow for replication, including how and when the intervention was administered. Hoffman et al. (2014) developed the Template for Intervention Description and Replication (TIDierR), to improve the completeness of reporting in order to improve replication of studies (Hoffman et al., 2014). **By examining research with the TIDieR, it can be established if a behavior change technique worked and also under what conditions it may work again in subsequent research.**

To replicate BCT it is important that they are described in detail and in terms of dose, method of delivery, who delivered it (Hoffman et al., 2014), and ideally by the name of the BCT

matched with the construct that was targeted. It is critical that future studies adhere to a framework that allows for comparison and replication. The TIDieR framework has 12 separate checkpoints. The first nine are covered in this review; they include (1) a brief name (2) why (3) what materials (4), what procedures (5) who provided (6) how (7) where (8) when and how much and (9) tailoring.

Item 1: Name

A brief name of the intervention should enable easy identification of the type of intervention (Hoffman et al., 2014). Titles were reviewed for the following: inclusion of strength training or resistance training, stated population, and naming of theory or theoretical constructs. Ott et al. (2009) was the only study to not have resistance training or strength training in the title. Each title stated the population that was studied. Fetherman et al. (2011), Millen & Bray (2009), Neupert et al. (2009), and Williams et al. (2016) and Winett et al. (2015) mention theory or specific constructs.

Table 8. TIDieR Checklist item 1, Brief Name

Item 1: Brief name	
Provide the name or a phrase that describes the intervention	
Author	Description
Fetherman et al. (2011)	A pilot study of the application of the Transtheoretical Model during strength training in older women
Plotnikoff et al. (2010)	Multicomponent, home-based resistance training for obese adults with type 2 diabetes: a randomized controlled trial.
Lubans et al. (2012)	Testing mediator variables in a resistance training intervention for obese adults with type 2 diabetes
Millen & Bray (2009)	Promoting self-efficacy and outcome expectations to enable adherence to resistance training after cardiac rehabilitation.
Neupert et al. (2009)	Exercise self-efficacy and control beliefs predict exercise behavior after an exercise intervention in older adults.
Ott et al. (2009)	Facilitative strategies, psychological factors, and strength/weight training behaviors in breast cancer survivors who are at risk for osteoporosis. .
Winett et al. (2015) Williams et al. (2016)	Theory-based approach for maintaining resistance training in older adults with prediabetes: adherence, barriers, self-regulation strategies, treatment fidelity, cost. Psychosocial mediators of a theory-based resistance training maintenance intervention for prediabetic adults.

Item 2: Why

The inclusion of theory in behavioral research can help others identify which elements of the study are essential (Hoffman et al., 2014). Theoretically based behavioral research informs which mediators should be targeted. Each author stated the theoretical background that the research was based upon.

Table 9. TIDieR Checklist item 2, Why

Item 2: Why	
Describe any rationale, theory, or goal of the elements essential to the intervention	
Author	Description
Fetherman et al. (2011)	The Transtheoretical Model informed the use of processes of change, decisional balance, and self-efficacy
Plotnikoff et al. (2010)	Social Cognitive Theory informed the hypothesized mediators of intention, planning, self-efficacy, outcome expectations, and social support.
Lubans et al. (2012)	
Millen & Bray (2009)	Theory based intervention targeting mediating variables (self-efficacy and outcome expectations) from Social Cognitive Theory.
Neupert et al. (2009)	Social cognitive theory informed the targeting of self-efficacy.
Ott et al. (2009)	The Transtheoretical Model informed the psychological constructs used in this study.
Winett et al. (20	The intervention was based on Social Cognitive Theory.
Williams et al. (2016)	

Item 3: What Materials

What is used to describe any materials used in the intervention including materials given to participants or materials used in the intervention or in the training of the providers. Identifying materials used is essential for study replication (Hoffman et al., 2014). Winett et al. (2015) was the only study to explicitly state where studies materials may be found (Winett et al., 2015). Fetherman et al. (2011) and Winett et al. (2015) described how resistance training coaches were trained.

Participants were provided with light weight dumbbells (Fetherman et al., 2011; Ott et al., 2009), with elastic bands (Millen & Bray, 2009; Neupert et al., 2009), with an at home multigym apparatus and dumbbells (Plotnikoff et al., 2010), and with a gym/lab and recreation center (Winett et al., 2015). Participants received manuals that described technique (Millen & Bray, 2009; Winett et al., 2015), videotapes (Neupert et al., 2009; Ott et al., 2009), and a book (Ott et al., 2009).

Table 10. TIDieR Checklist item 3, What Materials

	Item 3: What materials
	Describe any physical or informational materials used in the intervention, including those provided to participants or used in intervention delivery or in training of intervention providers. Provide information on where the materials can be accessed (such as online appendix, URL
Author	Description
Fetherman et al. (2011)	Both groups participated in the StrongWomen Program. The intervention group received a TTM based goal-setting worksheet (Table 3). Undergraduates were certified with the StrongWomen Program. The intervention group also received a single 10-minute counseling session with the primary investigator. Participants used light weight dumbbells.
Plotnikoff et al. (2010) Lubans et al. (2012)	Individuals randomized to the RT group were provided with a multigym apparatus and dumbbells. Individuals in the control group did not receive anything. N/A for BCT's
Millen & Bray (2009)	Cardiac patients were provided an *instructional manual* designed to enhance their motivation, self-efficacy, and outcome expectancy to carry out upper-body strength training exercises. Participants used elastic bands.
Neupert et al. (2009)	Participants received the Strong for Life treatment program which is a *35-minute videotaped program* of 10 exercises performed by a trained leader. Participants viewed a motivational videotape. Participants used elastic bands.
Ott et al. (2009)	Each participant received a copy of the book and video, *Strong Women Stay Young*. Participants used light weight dumbbells. A template was developed for coaching that was specific to low ratings on self-efficacy and the change processes.
Winett et al. (2015) Williams et al. (2016)	All participants received an *8-page manual* describing the rationale, principles, and the specific techniques of RT within the study protocol. The manual can be found on the resist diabetes website. Trainers have appropriate certifications and adequate social skills. Participants had access to a gym/lab and a recreation center.

Item 4: What Procedures

The procedures section describes the processes or activities the intervention provider carried out (Hoffman et al., 2014). Of importance is the application of the RT intervention, existence of a comparison group, and the application of the BCT's. Fetherman and colleagues' participants performed wide leg squats, standing leg curls, knee extensions, side hip raises, biceps curl, overhead press, bent forward fly and toe stands. All sessions were supervised and lasted one hour per day and were done two times per week (Fetherman et al., 2011). Plotnikoff et al. (2010) had participants perform eight exercises, four were core exercises that did not change (squats, seated row, chest press, and shoulder press) and four were assistance exercises that

changed half-way through the study (lunges, lat pull down, standing triceps extension, standing pulley abdominal twist, biceps curls, triceps press, reverse rhomboid fly, lateral pull deltoid raise, and pulley abdominal curls). Sessions were supervised but with faded contact (Plotnikoff et al., 2010). Millen and Bray (2009) had participants complete six upper-body exercises including biceps curls, triceps pushdowns, seated rows, shoulder shrugs, front arm raises, and seated chest press. No sessions were supervised (Millen & Bray, 2009). Neupert et al. (2009) had participants incorporate diagonal and rotational motions with an elastic band. Exact exercises were not specified. Participants received two home visits (Neupert et al., 2009). Participants in the study by Ott et al. (2009) completed knee extensions, side hip raises, hip extension, biceps curls, overhead triceps, upward row, toe stand and heel stand. Sessions were supervised (Ott et al., 2009). Winett et al. (2015) had participants perform a leg press, leg extension, leg curl, calf raise, chest press, pulldown, shoulder press, row, seated dips, abdominal crunch, lower-back extension, rotary torso (Winett et al., 2015).

One study had no comparison group (Ott et al., 2009), three had a waitlist control (Plotnikoff et al., 2010; Millen & Bray, 2009; Neupert et al., 2009), one had a strength training only comparison group (Fetherman et al., 2011) and one compared a high dose behavior change intervention to a low dose behavior change intervention (Winett et al., 2015). Lubans et al. (2012) and Williams et al. (2016) specified the constructs were targeted with the behavior change intervention. Millen and Bray (2009) relied on a manual for the delivery of behavior change techniques (Millen & Bray, 2009).

Table 11. TIDieR Checklist item 4, What Procedures

Item 4: What procedures	
Describe each of the procedures, activities, and/or processes used in the intervention, including any enabling or support activities	
Author	Description
Fetherman et al. (2011)	Each group participated in the StrongWomen Program. Table 2 provides session details. Participants in the intervention group received a single counseling session. Strength training only comparison group. For behavior change group the goal was to enhance self-efficacy, decisional balance, and stage of change through goal setting and 10-minute counseling session.
Plotnikoff et al. (2010) Lubans et al. (2012)	Participants in the RT group performed a structured exercise program on 3 nonconsecutive days per week. Eight exercises were performed per session, In the first two weeks, the exercise specialist supervised all three sessions, two times per week in weeks 3-4, one time per week in weeks 5-8, and in the last 8 weeks sessions were supervised biweekly. Waitlist control BCT's are described (Lubans; Table 1). No information on how they were delivered (i.e. when, how frequently)
Millen & Bray (2009)	Participants received an orientation to the 6 upper-body exercises. Waitlist control. Behavior change techniques were provided in the manual.
Neupert et al. (2009)	Strong for Life treatment program. Participants in the treatment were instructed to exercise three times per week with a videotaped program consisting of 10 exercises. Wait-list control Therapist used cognitive strategies to enhance each subject's positive attitudes and beliefs related to exercise.
Ott et al. (2009)	Exercise trainers instructed the women during 2 home visits 1 week apart on progressive strength training based on Strong Women Stay Young. Women were instructed to engage in RT twice weekly. No comparison group. Utilized processes of change from TTM and a template for coaching-specific to low rating on self-efficacy and processes of change.
Winett et al. (2015) Williams et al. (2016)	This study had 4 phases: initial; supervised RT (3 months); transition (3 weeks); maintenance (6 months), and no contact (6 months). See Table 3 in Winett (2015). Low dose vs high dose behavior change condition. BCT procedures presented in Table 3 (Winett et al., 2015) and in Table 1 (Williams et al., 2016)

Item 5: Who Provided

For each category of an intervention, the expertise/background, or training of any

providers should be specified. Who provided may also refer to the training competency of the

provider. Intervention components relate to who provided the resistance training intervention and

who provided the behavior change intervention (Hoffman et al., 2014). The participants in the

study by Millen and Bray (2009) were transitioning out of cardiac rehabilitation; there was no

description as to who familiarized participants with the exercises. Exercises were instructed by

certified or trained trainers for four of the studies (Fetherman et al., 2011; Plotnikoff et al., 2010; Ott et al., 2009, Winett et al., 2015) and by a physical therapist in one study (Neupert et al., 2009). Winett et al. (2015) describes the training of providers (see Table 2 in Winett et al., 2015).

Participants received behavior change interventions through different providers. Fetherman et al. (2009) stated the intervention was provided by the primary investigator with no description on the investigators background. Lubans et al.'s (2012) secondary analysis report that the behavior change techniques were provided by personal trainers. Millen and Bray had the behavior change intervention come from a manual (Millen & Bray, 2009). Neupert et al. (2009) had physical therapist provide the behavior change intervention. Winett et al., (2015) state that the follow-up coordinator provided some of the behavior change intervention. Their research states that the follow-up coordinator was trained, although specific background was not mentioned (Winett et al., 2015).

Table 12. TIDieR Checklist item 5, Who Provided

Item 5: Who provided	
For each category of intervention provider (such as psychologist, nursing assistant), describe their expertise, background, and any specific training given	
Author	Description
Fetherman et al. (2011)	All exercise instructors were undergraduate exercise science students (under the direct supervision of the primary investigator) who received certification to conduct the StrongWomen Program. Behavior change worksheet was facilitated by the primary investigator.
Plotnikoff et al. (2010) Lubans et al. (2012)	A qualified exercise specialist (certified personal trainer) ensured that exercises were being performed safely and within the prescribed intensity range. The secondary analysis reports that the personal trainers provided the BCT's.
Millen & Bray (2009)	N/A
Neupert et al. (2009)	A physical therapist provided the intervention. Training in behavioral coaching was not discussed.
Ott et al. (2009)	A research nurse took the baseline data and implemented the facilitative strategies based on the TTM. Exercise trainers who were trained by an experienced exercise physiologist instructed the women.
Winett et al. (2015) Williams et al. (2016)	All exercise trainers had proper certifications and training for the program. The follow-up coordinator provided the behavioral intervention. The intervention was also aided with the use of the Resist Diabetes website.

Item 6: How

How describes the modes of delivery. This includes delivery and settings (i.e. 1:1 or

group setting) (Hoffman et al., 2014). Exercise sessions were conducted face-to-face to varying

degrees (Fetherman et al., 2011; Plotnikoff et al., 2010; Neupert et al., 2009; Winett et al., 2015).

Behavior change interventions were provided through several channels including face-to-face

(Fetherman et al., 2011; Neupert et al., 2009; Ott et al., 2009; Winett et al., 2015), through

printed materials (Millen & Bryan, 2009), telephone calls (Neupert et al., 2009; Ott et al., 2009;

Winett et al., 2015), Skype (Winett et al., 2015) and through internet websites (Winett et al.,

2015).

Table 13. TIDieR Checklist item 6, How

Item 6: How	
Describe the modes of delivery (such as face to face or by some other mechanism, such as internet or telephone) of the intervention and whether it was provided individually or in a group	
Author	Description
Fetherman et al. (2011)	Exercise sessions were conducted face to face with the student trainers. The primary investigator attended 40% of the STBC group exercise sessions. Initial session was delivered in a group setting. The counseling session was delivered individually.
Plotnikoff et al. (2010)	Exercise specialist supervised 18 of 48 at home workouts with faded contact.
Lubans et al. (2012)	N/A for BCT's
Millen & Bray (2009)	Through an educational manual
Neupert et al. (2009)	Face to face with the physical therapist and through motivational videotapes. Participants were also called bimonthly.
Ott et al. (2009)	Exercise sessions conducted through two home visits. Through phone calls and home visits
Winett et al. (2015) Williams et al. (2016)	Face-to-face and internet-based treatments were available to both groups. Contacts with high dose condition were through phone calls or facetime. Participants also used the Resist Diabetes website.

Item 7: Where

Where describes the location that the intervention occurred at. Four of the six studies had participants complete RT in their homes (Plotnikoff et al., 2010; Millen & Bray, 2009; Neupert et al., 2009; Ott et al., 2009). Fetherman et al. (2011) recruited participants from a senior center but it was not explicitly stated where they completed RT. Winett et al. (2015) had participants perform RT in a research gym/lab and in an offsite facility.

Plotnikoff et al. (2010) did not provide information on where the application of the BCT's took place, nor did Fetherman et al. (2011). Millen and Bray had their BCT's implemented in the manual they provided participants with. Neupert et al. (2009) applied BCT's at participants homes (Neupert et al., 2009) as did Ott et al. (2009) with the addition of phone calls (Ott et al., 2009). Winett et al. (2015) applied techniques using the Resist Diabetes website.

Participants learned how to use the website in the lab/gym. Contact checkups were conducted in person at the lab/gym and through phone or Skype calls (Winett et al., 2015).

Table 14. TIDieR Checklist item 7, Where

Item 7: Where
Describe the type(s) of location(s) where the intervention occurred, including any necessary infrastructure or relevant features

Author	Description
Fetherman et al. (2011)	Participants were recruited from two senior centers in northeastern Pennsylvania Unclear where BCT's were given.
Plotnikoff et al. (2010) Lubans et al. (2012)	The intervention occurred in participants homes. N/A for BCT's
Millen & Bray (2009)	Home based RT BCT's were in the manual participants received
Neupert et al. (2009)	Home based RT BCT's applied at home
Ott et al. (2009)	Home based RT BCT's implemented in home visits and through phone calls
Winett et al. (2015) Williams et al. (2016)	The first three-month phase occurred in the research gym/lab. The second and third phase occurred in an offsite facility and in the research gym/lab. Utilized the Resist Diabetes website for BCT's, learned how to use the website in the lab/gym. Contacts (check-ups) were first face-to-face with the follow-up coordinator in the lab/gym and then were conducted by phone or Skype

Item 8: When and How Much

When and how much describes the number of times the intervention was delivered and over what period of time including the number of sessions, including duration and dose (Hoffman et al., 2014). The dose of behavior change sessions varied. Fetherman et al. (2011) provided participants with a single 10-minute counseling session. Neupert et al. (2009) provided participants with two sessions. The time of the sessions was not provided. Millen and Bray (2009) only provided a manual, so no behavior change sessions were completed. Winett et al. (2015) specified that participants in the high dose condition received nine contact periods during maintenance which lasted 15 to 20 minutes. These contacts occurred bimonthly for the first three months and then once per month for the last three months. Participants in the low dose condition

met face-to-face, by phone, or Skype with the coordinator only twice during the follow-up phase.

Plotnikoff et al. (2010) and Lubans et al. (2012) did not specify how many behavior change

sessions occurred. Ott et al. (2009) provided participants with monthly sessions for 6 months.

The time of the sessions was not provided (Ott et al., 2009).

Table 15. TIDieR Checklist item 8, When and How Much

Item 8: When and how much	
Describe the number of times the intervention was delivered and over what period of time including the number of sessions, their schedule, and their duration, intensity, or dose	
Author	Description
Fetherman et al. (2011)	Primary researcher discussed the responses individually with each participant in a single 10-min individual counseling session at the end of four weeks.
Plotnikoff et al. (2010) Lubans et al. (2012)	Participants completed up to 48 resistance training sessions. Intensity of the resistance training exercise progressively increased. N/A for BCT's
Millen & Bray (2009)	Before the study began, participants received an educational manual and nothing else.
Neupert et al. (2009)	Participants received two home visits from a physical therapist. The first visit consisted of exercise instruction including guidelines for how to increase RT levels. During the first session the physical therapist used cognitive strategies to enhance each subject's positive attitudes and beliefs related to exercise. The second session occurred two to three weeks later.
Ott et al. (2009)	Monthly for 6 months. The time of the coaching sessions was not mentioned.
Winett et al. (2015) Williams et al. (2016)	In phase 1, there were twice weekly face-to-face sessions with one trainer for one to two trainees. Sessions last 30 to 40 minutes. In the transition stage high dose participants received 4 sessions in the gym/lab, three sessions in the participants new facility, and one additional session in the lab/gym. Low dose participants received one instructional session in the lab/gym, one non-training orientation in the new facility, one training session in the new facility, and a non-training session in the lab/gym to report any issues or barriers. During maintenance, high dose was scheduled for nine 15-20-minute follow-up contacts, bimonthly for the first three months and then once per month for the last three months.

Item 9: Tailoring

Tailoring describes if the intervention was personalized. In tailored interventions, not all

participants will receive the same intervention (Hoffman et al., 2014). Only Winett et al. (2015),

specified tailored feedback (Winett et al., 2015). Fetherman et al. (2011) and Ott et al. (2009)

had participants engage in processes they were not currently using or specifically targeted

mediators that had low ratings (Fetherman et al., 2009; Ott et al., 2009). Winett et al. (2015)

provided participants in the high dose condition with tailored intervention components whereas

the low dose condition received generic messages. Because Millen & Bray (2009) utilized a

manual, all participants received the same intervention. Plotnikoff et al. (2010) and Neupert et al.

(2009) did not specify tailoring.

Table 16. TIDieR Checklist item 9, Tailoring

Item 9: Tailoring	
If the intervention was planned to be personalized, titrated or adapted, then describe what, why, when, and how	
Author	Description
Fetherman et al. (2011)	Participants were encouraged to use at least one process of change that they were not currently using.
Plotnikoff et al. (2010) Lubans et al. (2012)	N/A
Millen & Bray (2009)	Each participant received the same manual
Neupert et al. (2009)	N/A
Ott et al. (2009)	The coaching intervention was based on low ratings that participants had.
Winett et al. (2015) Williams et al. (2016)	Participants in the high dose condition received tailored intervention components, the low dose received generic messages.

Summary

One area that interventions can improve upon is item 8: when and how much. This is the

area that had the least amount of detail in the RT literature. For example, Lubans et al. (2012) did

not specify either component of item number 8. Fetherman et al. (2011) provided a brief 10-

minute intervention. Ott et al. (2009) did not specify the length of time of the behavior change

intervention. Next, is item 9; only one study (Winett et al. 2015) specified tailoring. Although

two (Fetherman et al., 2011; Ott et al., 2009) inferred that the intervention was individualized.

Plotnikoff et al. (2010), Millen and Bray (2009), and Neupert et al. (2009) did not specify if the

intervention was tailored or generic. Through the lens of the TIDieR framework, the most

rigorous study was conducted by Winett et al. (2015). This study provided details for each

category in the checklist. Therefore, this study served as a basis for replication under several caveats including time and mechanism of delivery (entirely digitally vs in person + digital).

Behavioral interventions would **benefit from the use of the TIDieR checklist.** Providing this information is invaluable for progressing behavioral research. If an intervention successfully changes targeted constructs, it is important to identify why it was successful. Similarly, if an intervention failed to change mediators it is also important to have all the information as to why it was not successful. Perhaps the dose of the behavior change intervention was aimed at self-efficacy. However, it was provided in a single dose by an untrained provider for 10 minutes. Rather than deem the behavior change technique ineffective, the conditions under which it was provided must be more closely examined. Behavior change research for RT is currently sparse. Future research in this field would be strengthened by providing this valuable information.

Which Constructs Mediate Behavior Change?

If a construct can be enhanced with a specific behavior change technique, under specific conditions (i.e. as specified in the TIDieR checklist), does this contribute to behavior change? This question would be useful in understanding the mechanisms through which an intervention works. Currently there are six RT studies that have applied behavior change techniques. Examining the current research can help inform which constructs should be targeted. Two studies have conducted mediation test. Williams et al. (2016) observed that changes in behavioral expectations and self-regulation were significant mediators of RT behavior (Williams et al., 2016). Lubans et al., (2012) also found that self-regulation was a significant mediator of RT behavior. **These two studies suggest that self-regulation and behavioral expectations are important targets for RT interventions (Williams et al., 2016).** Due to the paucity of research, reviewing theory to examine where self-regulation and behavioral expectations fit can help to determine if other constructs should be targeted.

The Intention-Behavior Gap

Studies using theories, such as the TPB (Bryan & Rocheleau, 2002; Courneya et al., 2004), Protection Motivation Theory (Plotnikoff et al.,2009), and Social Cognitive Theory (Gao & Kosma, 2008), place intention as the most proximal predictor of behavior. With the exception of Plotnikoff et al. (2009) and Lubans et al. (2012) the majority of studies found positive associations with intentions and resistance training behavior. To illustrate, Vallerand et al. (2016) noted that of those who intended to do strength training, 51% did strength training exercise whereas only 4% without an intention did strength training. Of those who met the strength training guidelines, 94% had an intention to do so (Vallerand et al., 2016). Furthermore, Dean et al. (2006) found that intention explained 40% of the variance in behavior (Dean et al., 2006). **Intention seems to be a potential precondition for behavior to occur.** Only one study has attempted to enhance intention (Plotnikoff et al., 2010). However, based on the TIDieR checklist, there is not sufficient detail to examine why intention did not change (Hoffman et al., 2014). However, **there may be other variables that mediate the relationship between intention and behavior**. A strength then of the TPB is the inclusion of intention and a weakness is a lack of inclusion of any variables that explain how intention is translated into behavior.

Based on the review of the literature, self-regulation is an important determinant of resistance training behavior. **Self-regulation skills such as planning, and goal setting are post-intentional variables.** That is, people cannot set a plan to do something that they have not formed an intention to do. Nor can people make goals for future behaviors unless they have formed an intention. In support of this, Paech and Lippke (2017) observed that intentions indirectly predicted behavior via the use of action planning (Paech & Lippke, 2017).

Because several studies have found no associations (Lubans et al., 2012; Plotnikoff et al., 2008), or indirect associations (Paech & Lippke, 2017) with intention and behavior there is the

possibility that **there may be a gap in identifying other constructs between intention and behavior in the conceptual models reviewed herein**. Furthermore, there is evidence that post-intentional constructs such as planning are not only predictive of behavior but are also malleable to change through behavior change interventions (Williams et al., 2016). **Therefore, models, frameworks, or theories that include post-intentional constructs could be useful for explaining resistance training behavior**.

In a systematic review, Rhodes and Yao (2015) identified several theories, models, and frameworks that examined the intention-behavior gap. For volitional behaviors, 11 theories were identified. Of those, the **Health Action Process Approach (HAPA)** and the Multi-Action Process Control Framework (M-PAC) have been used in RT studies. Of the reviewed models in the Rhodes and Yao paper, the HAPA and the M-PAC framework were the most commonly used model for physical activity (Rhodes & Yao, 2015). Models such as the HAPA suggest that task self-efficacy and outcome expectations contribute to intention formation. Intentions are translated into action **with maintenance self-efficacy and with the use of planning.**

Discussion
Proposed Conceptual Framework for Resistance Training Research
The HAPA is a theoretical model that has been utilized in physical activity research (Rhodes & Yao, 2015). However, to date it has only been used in one resistance training study (Paech & Lippke, 2017). **The HAPA is appealing as a theory to understand resistance training because it holds many of the established psychological correlates of behavior, specifically a self-regulatory component which mediates the intention-behavior relationship.**

In conjunction with the reviewed evidence on resistance training correlates (Rhodes et al., 2017) and the systematic review on intention translation theories (Rhodes & Yao, 2015), the

constructs of task self-efficacy, outcome expectations, attitudes, intentions, maintenance self-efficacy or confidence to overcome barriers, and planning to overcome barriers would be useful in a conceptual model to explain resistance training behavior. The HAPA presents a mediator model that allows for the prediction of behavior and explains the assumed causal mechanisms of behavior change. Different research questions may employee more parsimonious models of the HAPA (Schwarzer, 2016). *Schwarzer considered the HAPA to be an open architectural framework that serves to guide research and practice. Therefore, studies may vary in the number and type of constructs that they employ* (Schwarzer, 2016). The HAPA recognizes that no one construct will change behavior. Rather they need to operate in concert (Schwarzer, 2016). Because of the flexibility of this model to include certain constructs (i.e. affective attitude, behavioral expectation) the HAPA a viable model for explaining resistance training behavior. Based on the observed correlates, the HAPA (Zhang et al., 2019) (Figure 1) is presented along with the proposed modification (Figure 2) for the purposed of understanding and studying resistance training behavior. In the first model removed constructs are highlighted in red. Volitional self-efficacy which is the capacity to overcome barriers and manage contingencies (Zhang et al., 2016) is replaced with behavioral expectations, the likelihood of engaging in a behavior in the face of barriers (Williams et al., 2015). Action planning is also removed. In the new model, affective attitudes are included as a predictor of intention.

Figure 3. Health Action Process Approach
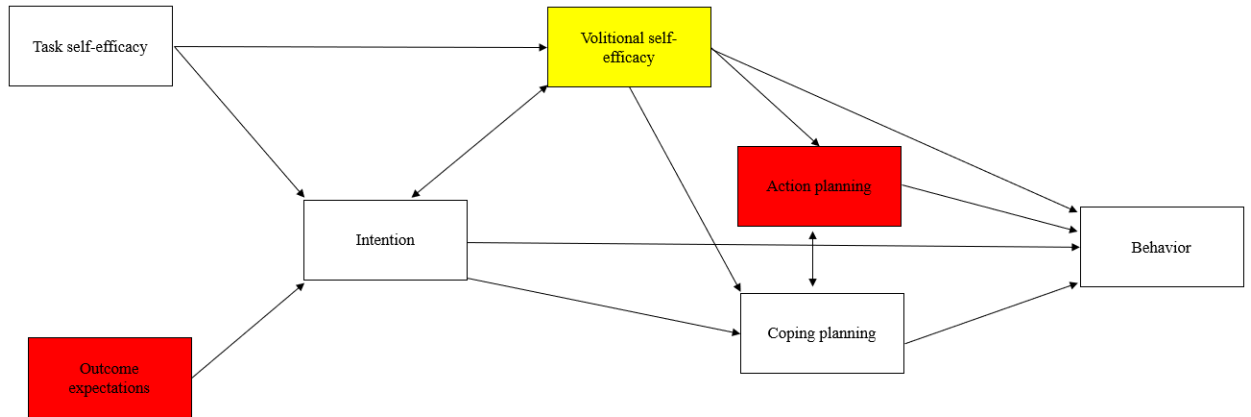
Figure 4. Proposed Model for the Current Research
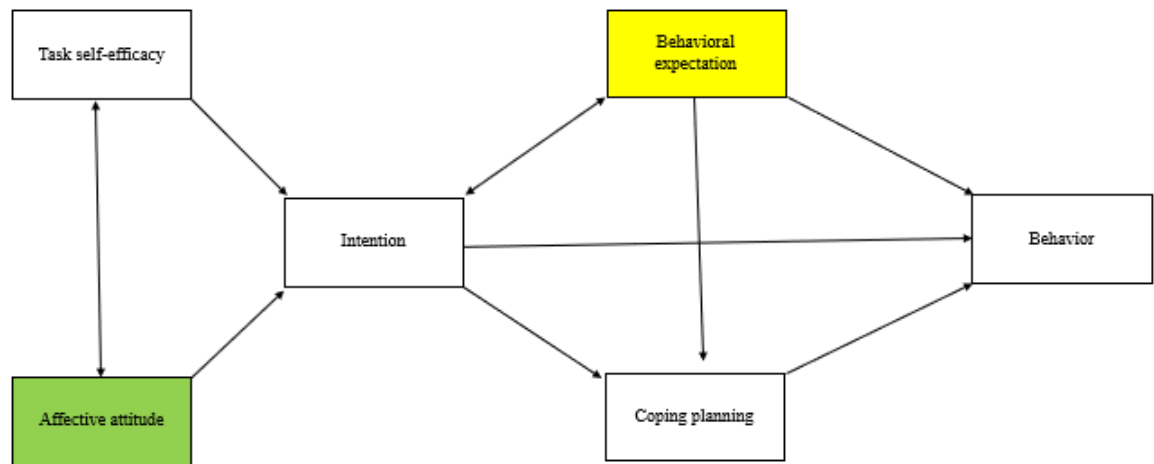
Delivery Mechanisms: eHealth Interventions

Item number 6 in the TIDieR system is "how", **which describes the mode of delivery**.

Several of the current RT studies utilized methods other than face-to-face to deliver the

intervention. These methods include though telephone calls and through Skype (Neupert et al., 2009; Ott et al., 2009; Winett et al., 2015). No RT research has been done that has examined a remote coaching only method of delivering BCT's. However, eHealth and telecoaching specifically may provide insight on the feasibility of a digitally based RT intervention. Eng (2001) defines eHealth as "the use of information and communications technology, especially the Internet, to improve or enable health and health care". These eHealth interventions have the capability of reaching more people than traditional face-to-face interventions in a time-efficient way (Eng, 2001).

In a recent study, Fischer et al. (2019) compared three arms of a telecoaching intervention. The coaching group received 12 bi-weekly phone calls that were 20 minutes in duration. Participants were asked to set and adapt goals, plan their physical activity behavior, report and overcome barriers, and to gradually habituate to a physically active lifestyle. A coaching and SMS group received the same coaching intervention but also received four tailored SMS prompts during each two-week period (48 messages in total). SMS prompts contained BCT's, feedback, PA knowledge, or a reminder. The control group received tailored information on how to apply BCTs in order to increase PA but did not have contact with the researchers. The coaching and coaching plus SMS groups reported greater increases in MVPA than the control group (Fischer et al., 2019). Meta-analysis suggest that internet-delivered programs have a small but positive effect on physical activity levels (Davies, Spence, Vandelanotte, Caperchione, Mummery, 2012). Furthermore, a 2012 review by Goode et al. found strong evidence for telephone-delivered physical activity interventions (Goode, Reeves, & Eakin, 2012). Due to the present circumstances surrounding the 2020 Covid-19 Pandemic, an internet based coaching

intervention conducted through digital platforms such as Zoom or Skype would be ideal to coach

RT and to also provide individuals with behavioral coaching sessions.

Summary

Given the health benefits of resistance training, the low and slowly increasing prevalence

rates, and paucity of research on apparently healthy individuals, theoretically driven

interventions are needed to increase the rates of participation among apparently healthy

individuals in order to prevent disease and disability. To successfully promote adherence and

adoption of resistance training, the correlates of resistance training need to be identified and

targeted. Although, the current research has employed several theories in their attempts to

understand resistance training behavior, only seven have examined some type of self-regulation

component and only three have attempted to enhance psychological determinants of behavior in

comparison to a control group.

Intention may be the product of constructs such as outcome expectations, self-efficacy,

attitudes, and PBC. Intention is likely a precondition for action, with very few people acting

without an intention. Intentions have an impact on resistance training behavior. However, self-

regulation and self-efficacy must also be considered. Gollwitzer and Sheeran highlight the point

that psychological determinants other than intention must be identified to understand why people

fail to follow through on their intentions and that self-regulatory strategies are needed to help

people follow through on their intentions (Gollwitzer & Sheeran, 2006).

Beyond the limited number of correlational or longitudinal studies examining the

relationships between psychosocial variables and resistance training there are very few RCT's

that have attempted to intervene on psychological determinants (Lubans et al., 2012; Millen &

Bray, 2009; Williams et al., 2016). With the limited number of RCT's it is challenging to

determine (1) which psychological variables are subject to change (2) what are the best methods

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to change these variables and (3) if these variables are enhanced, what are their effects on behavior. Within the current research on resistance training, which includes longitudinal data and RCT's, planning is an important determinant to target for behavior to occur. Task self-efficacy and attitudes contribute to favorable intentions and intentions are likely a precondition for behavior to occur. Individuals may also need confidence in their abilities to overcome barriers to translate intentions into behavior. Of the RCT's that have been conducted, none have been done with a healthy young population. RCT's have been conducted with diabetics, prediabetics, cancer survivors, and older adults. While the utility of engaging in resistance training to slow disease and age-related loss of function is necessary, it is also crucial that this form of physical activity be addressed in younger disease-free individuals to prevent negative health sequelae. A clear conceptual framework, identification of modifiable variables, as well as the effects of modification on behavior is a needed step to understand and help design resistance training behavior change programs.

Models must first be identified for use that include key constructs that have been shown to be related to resistance training behavior. Because the HAPA is an existing model that includes many of the psychological correlates of resistance training, it may be ideal for understanding why individuals engage in resistance training and may give direction to which constructs researchers should attempt to intervene on. Based on the HAPA, research that aims to enhance resistance training behavior must consider how to enhance behavioral intentions and then also how to translate good intentions into behavior. Thus, a dual approach that targets intention strengthening and self-regulation should be utilized in resistance training research. Therefore, the aims of the present research are once again:

Specific Aims

Specific Aim 1: To assess if a digital resistance training intervention plus Behavioral Coaching

based on the HAPA can increase resistance training behavior in novice participants over the

same digital resistance training intervention (*Control*).

Specific Aim 2: To examine the mechanisms through which the intervention worked.

Sub aim 1: To examine if the *Intervention* group has more positive changes in self-

efficacy, intention, behavioral expectation, and coping planning than the *Control* group.

Sub aim 2: To examine if changes in self-efficacy, intention, behavioral expectations, and

coping planning predict changes in behavior.

Sub aim 3: To examine the mechanisms through which the *Intervention* exerted its

effects.

CHAPTER 3

DESIGN AND METHODS

Study Overview

This randomized control trial sought to assess if a digital resistance training intervention plus Behavioral Coaching intervention based on the Health Action Process Approach (HAPA) increased resistance training behavior in novice participants over the same digital resistance training intervention without behavioral coaching (*Control*). Participants in both the control and intervention group attended 2 virtually coached RT sessions prior to randomization (Phase I: guided practice). Participants in both the control group and intervention groups were given access to the same four separate training videos (RTinHome.com) throughout the next two phases (Phase II: intervention; Phase III: follow-up). However, the intervention group also received behavioral coaching sessions that aim to enhance intentions, behavioral expectations and coping planning whereas the control group received no further information. Phase II, the intervention phase, was conducted remotely over 4 weeks (Figure 5). In Phase III, participants no longer received an active intervention. At the end of this four-week follow-up phase, there was a final assessment to assess RT behavior (Phase III: follow-up).

To enhance internal and external validity, **this study utilized the Template for Intervention Description and Replication (TIDieR) checklist** (Table 17; Hoffman et al., 2014). The TIDieR is an extension of item 5 of the CONSORT 2010 statement and item 11 of the SPIRIT 2013 statement in the form of a checklist with the objective being to improve the completeness and replicability of interventions (Hoffman, 2014).

Figure 5. Overview of Study Timeline

Duration		One week				Four weeks	Four weeks
Phase		Phase 1 Guided RT				Phase 2 Intervention	Phase 3 Follow-up

					Training videos+ educational packet + Behavioral coaching at the end of week 2, 3, 4 and 5	
Training trainers	Recruitment	Guided resistance training	Randomization	→ Intervention → Control group		Follow-up
					Training videos+ educational Packet	

Materials	RT band and dumbbell Access to training app Zoom coaching	Access to video workouts

Table. 17 TIDieR Checklist for Proposed Study (Hoffman et al., 2014).

Item number	Item
Brief name	
1	
Provide the name or a phrase that describes the intervention	A digital Health Action Process Approach intervention to promote resistance training behavior in healthy adult novices
Why	
2	
Describe any rationale, theory, or goal of the elements essential to the intervention	This study is based on the Health Action Process Approach
What	
3	
Materials: Describe any physical or informational materials used in the intervention, including those provided to participants or used in intervention delivery or in training of intervention providers. Provide information on where the materials can be accessed (such as online appendix, URL	All participants received the following (2) dumbbells and a single band (2) access to Vimeo prerecorded training videos which are hosted on rtinhome.com and (3) a digital education packet.
4	
Procedures: Describe each of the procedures, activities, and/or processes used in the intervention, including any enabling or support activities	Three phase intervention with two Zoom based training sessions in Phase I, the use of action planning, coping planning, and SMS prompting in Phase II for the intervention group.
Who Provided	
5	
For each category of intervention provider (such as psychologist, nursing assistant), describe their expertise, background, and any specific training given	Certified personal trainers (NSCA, ACSM, or NASM) will provide the instructions in phase 1. The PI will provide the Digital RT + Behavioral Coaching in phase 2 and phase 3. The certified personal trainers will undergo training.
How	
6	
Describe the modes of delivery (such as face to face or by some other mechanism, such as internet or telephone) of the intervention and whether it was provided individually or in a group	RT coaching sessions are conducted over Zoom. Digital RT + Behavioral conducted over Zoom. Training videos are hosted on the website RTinHome.com. Graphic material and educational manuals will be hosted on RTinHome.com
Where	
7	
Describe the type(s) of location(s) where the intervention occurred, including any necessary infrastructure or relevant features	All training will occur in participants' homes.
When and How Much	
8	
Describe the number of times the intervention was delivered and over what period of time including the number of sessions, their schedule, and their duration, intensity, or dose	A total of two guided RT sessions, a total of four coaching sessions, separated by 1 week lasting 20 minutes. Sessions focusing on enhancing coping planning and behavioral expectations.
Tailoring	
9	
If the intervention was planned to be personalised, titrated or adapted, then describe what, why, when, and how	The behavioral intervention starts with a script but the aspects of the script will be tailored to participants needs.

Study Aims and Hypotheses

This aim of the present RCT is to assess the effectiveness of a *Behavioral Coaching* intervention based on the HAPA on initiating home based RT. It is hypothesized that the HAPA-based intervention will produce superior behavioral outcomes in terms of days of RT completed. Measurements of behavior occurred throughout Phases II and III. The secondary aim of this study is to examine the mechanisms through which the intervention worked. Specifically, we sought to examine the effects of the putative mediators of the intervention group vs the control group on RT behavior. Mediators included behavioral intention, behavioral expectation, affective attitudes, task self-efficacy and coping planning. We hypothesized that (a) relative to participants in the control condition, participants in the intervention would show more positive changes in intention, behavioral expectations, and coping planning, (b) changes in intention, behavioral expectations and coping planning will be predictive of RT behavior at the follow-up time point and (c) the relative effects of the intervention on RT behavior would occur through coping planning and behavioral expectations.

Study Methods

Overview

This randomized control trial involved three Phases: 1 week of guided digital RT over two sessions, 4 weeks of continued self-directed home-based digital RT plus coaching in the intervention group, and a four-week follow-up period. Psychological constructs were measured after the first guided digital RT session, after the second digital RT session in Phase I, at the end of Phase II, and at the end of Phase III. Behavior was assessed at the end of Phase II and Phase III (Table 18.). After Phase I was completed, participants were stratified based on sex and randomized to the intervention or control groups. Phase II lasted for four weeks; participants in the intervention received four Zoom coaching sessions with the PI. Once Phase II was complete Phase III began. There was no contact with participants during the follow-up Phase III period.

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Table 18. Assessment and Measures Timeline

					Data collection time point				
Phase	1	2				3			
Week	1	2	3	4	5	6	7	8	9
Psychological questionnaires	X	X				X				X
RT behavior					X				X

Participants and Recruitment

Participants were recruited on an ongoing basis via campus wide emails. Participants who responded to emails were given a Qualtrics eligibility survey. Screening questions addressed exclusion criteria. Healthy young adults (aged 18-35 years) who participate in RT one time per week or less were considered eligible (ie., do not meet the current guidelines). Healthy was defined as those individuals without serious injury, long-term physical incapacity, or suffering or rehabilitating from chronic conditions and risk factors that require medication, assessed in the following ways. Participants were also asked their age. Exclusion criteria included being younger than 18 or older than 35. Participants were screened via the Physical Activity Readiness Questionnaire (PARQ+) and the protocol established by the PAR-Q+ Collaboration (Warburton et al., 2011). Individuals who checked yes to any general health questions were not eligible to participate. Lastly participants were asked about current RT participation. An adapted version of the Godin Leisure Time Exercise Questionnaire (Plotnikoff et al, 2008) was used to assess RT behavior. RT was defined as "all exercises intended for enhancing muscle strength and endurance including weight bearing exercises (e.g. crunches, push-ups, squatting), exercises using simple dumbbells, tubes, and exercises using machines and barbells" (Harada et al., 2008).

Participants were asked the average number of times in the past month that they engaged in RT. If participants met the RT guidelines they were not be eligible for the study.

Eligible participants provided an email and contact number (Figure 8). Ineligible participants received a message stating that they are ineligible along with an email to see if they have questions. Eligible participants were contacted to schedule the Phase I baseline guided practice RT session. Eligible participants who were interested in the study were given a RT starter kit which included an elastic band and a pair of light weight dumbbells. The email (Appendix F) also included details about the session along with instructions on proper attire (See Figure 8 for flow chart of eligibility).

Figure 8. Flow Chart of Survey Eligibility Criteria

	Eligible	Ineligible
Age	18-35	<18 or >35
Par-Q+	No contraindications	Any contraindications
RT history	Not meeting RT guidelines	Meeting RT guidelines

Provide email and contact number
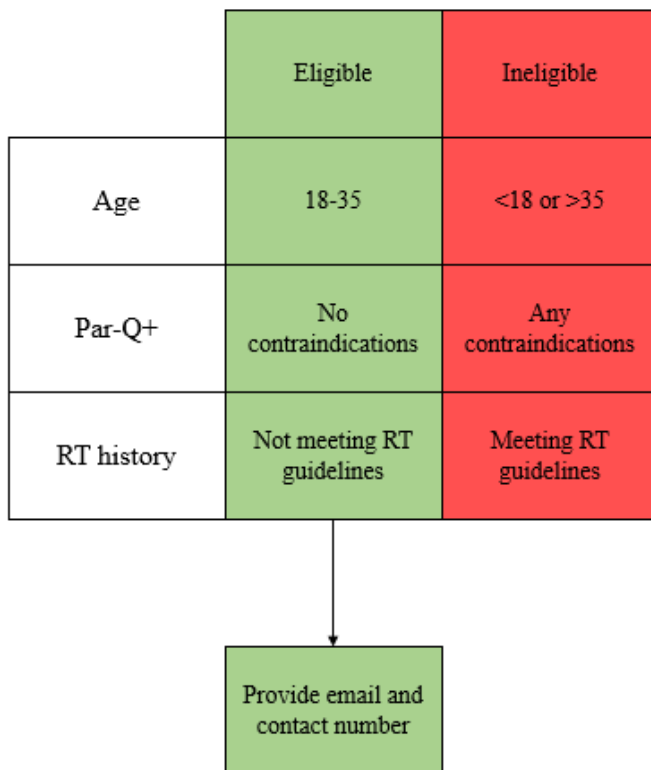
Training the Trainers

The home-based digital RT program for all participants consisted of free weight, body weight, and band resisted movements that train the full body. Prior to commencing the study, student assistants with personal training experience were recruited by the PI to be trained to serve as the personal trainers for the study. Students with personal training certifications through NSCA, ACSM, or NASM and upper classman status were recruited. These assistants were recruited via University internships/ independent study and through the student gym which employs student personal trainers. Two student assistants were recruited. Once recruited, students spent two virtual sessions with the PI learning the RT routine, standardized coaching cues, and ways to correct common errors that may be observed in each exercise. Trainers gained access to the RT videos and digital training manuals that were provided to participants. On the third training session the student assistants completed a mock run of the training program to ensure competency with cueing and error correction.

Consent and Overview of Training

Eligible participants consented to the study over the phone with the PI (See Appendix D). Once participants consented, they were emailed to schedule their first session. Once a date and time was provided, participants were emailed their scheduled time with a Zoom invitation, information on the session, suggestions for proper attire and a contact number to reach the trainer they were to work with. Participants were also sent a reminder of their appointment the day prior to their session via email. After the first training session the personal trainer scheduled the next session with the participant. In the follow-up training session participants learned new exercises.

Participant Safety

In the event of an adverse incident (e.g. musculoskeletal injury, pain) participants were instructed to immediately inform a member of the study staff (PI or personal trainer) by phone or through email. For minor problems such as prolonged soreness we recommended extensions of

rest periods and reductions in training loads. All adverse events were reported to the IRB within 24 hours of notification by the participant.

Phase I: Guided RT

All digital RT were conducted in the participants home through Zoom. Participants worked with the same trainer for both sessions. The two digital RT sessions in Phase I were conducted on nonconsecutive days. Each session lasted 30 to 40 minutes. All participants began the program with a single digital RT session led by a certified personal trainer/ student research assistant (RA). Techniques that have been shown to enhance task related self-efficacy for physical activity include providing instruction (Williams & French, 2011). Under Michie et al's. (2013) guidelines for reporting behavior change techniques we report the use of; *instructions on how to perform a behavior* and; *demonstration of the behavior* (Michie et al., 2013). Each participant watched a recorded video that demonstrates the exercise while listening to verbal cues. Participants completed each exercise under the supervision of the trainer who will provide corrective and encouraging feedback.

The American College of Sports Medicine recommends unilateral and bilateral single- and multiple-joint exercises with an emphasis on multiple-joint exercises for maximizing overall muscle strength in novices (ACSM, 2009). For novice to intermediate training, it is recommended that free-weight as well as machine exercises are included. It is also recommended that novice individuals train the entire body for two to three days per week with moderate loads in the 8-12 repetition range (ACSM, 2009). Exercises were chosen that do not require equipment outside of dumbbells or bands. Per the ACSM recommendations, the selected exercises were primarily multi-joint, included unilateral and bilateral aspects, and train all the muscle groups without requiring skill beyond what a novice may have.

Furthermore, to comply with ACSM recommendations, all exercises were performed for three sets of ten repetitions or for time if isometric. Participants were asked to rate their perceived exertion using a Borg scale after each exercise. The goal was to keep RPE's at 12-16 on the 20-point scale. Difficulty was adjusted by adding or reducing load, repetitions (maintaining 8-12 repetition range), modifying rest, or adding or reducing band resistance to maintain an RPE of between 12-16.

Participants were provided with equipment including 2 dumbbells each weighing 10lbs, and a resistance band. They received these prior to starting their sessions and were able to keep them as an incentive for participating. Participants learned several RT exercises that target the whole body. When the guided digital RT was complete, participants received four videos with different RT routines. All routines had four common core exercises and five rotating exercises. The four core RT exercises included a *dumbbell squat*, a *dumbbell overhead press*, a *dumbbell lunge*, and *band row*. The four routines can be found in Table 19 and can also be seen at the website www.RTinHome.com, a website created by the PI for this trial.

Assessment in Phase I was conducted via Qualtrics and was emailed to the participants at the end of each session. The first survey addressed task self-efficacy and affective attitude and took less than 5 minutes. After completion of the second guided session, all participants filled out a questionnaire that assesses task self-efficacy, affective attitudes, intention, behavioral expectation, and coping planning via Qualtrics. Because more measures are included, the survey took between 5 and 10 minutes.

Table 19. Resistance Training Routines for Both Conditions

Circuit	Routine 1 Exercise Sets x Reps/Time	Routine 2 Exercise Sets x Reps/Time	Routine 3 Exercise Sets x Reps/Time	Routine 4 Exercise Sets x Reps/Time
1	Dumbbell squat 3x10	Overhead press 3x10	Dumbbell lunge 3x10	A1. Band row 3x10
	Dumbbell Curl 3x10	Dumbbell lunge 3x10	Band row 3x10	A2. Shoulder taps 3x10
	Dumbbell front raise 3x10	Bird dog row 3x10	Band curl 3x10	A3. Overhead press 3x10
2	Squat hold 3x10	Skull crushers 3x10	Dumbbell squat 3x10	B1. Dumbbell lunge 3x10
	Overhead press 3x10	Band row 3x10	Pulse squat 3x10	B2. Plank 3x20 sec
	Dumbbell lunge 3x10	Dumbbell squat 3x10	Overhead press 3x10	B3. Dumbbell squat 3x10
3	Band row 3x10	Calf raises 3x10	Band press 3x10	C1. Skull crusher 3x10
	Leg lowering 3x10	Romanian deadlift 3x10	C2. Leg lowering 3x10	C2. Squat to press 3x10
	Plank 3x20 sec	Push-up 3x10	C3. Mountain climbers 3x10	C3. Dumbbell curl 3x10

Phase II: Common Components and Randomization

All participants attended two digital RT sessions prior to randomization. The personal

trainer informed the PI when the 2nd guided session was completed and the PI sent the participant

their last survey prior to randomization. Following the last survey, the PI used the random

numbers generator to randomize participants. Regardless of condition, the PI sent participants a

link to a website designed for this study (www.RTinHome.com). The website included the

following 1) RT guidelines, the health benefits of RT, 2) four videos of self-guided workout

routines and 3) detailed instructions on the exercises they completed in Phase I (Appendix G).

The RT exercise options for Phase II of the program were identical to the first. However, the exercises were varied to form four different routines.

Control Group
Participants in the control group were encouraged via email to think about the best days and times that they can engage in RT. However, other than this they did not receive contact with anyone from the study outside of when measurements were taken.

Intervention Group
For those randomized to the intervention group, in Phase II, there were several additions not present in the control condition. First, the intervention began within one week after randomization. In addition to the RT educational packet and videos, participants in the intervention group underwent a HAPA based intervention using interactive self-regulation procedures related to RT behaviors. BCT's and targeted constructs can be found in Table 20 (Michie et al., 2013). Participants met with the PI for 10 minutes, once per week, for four weeks.

Table 20. Summary of Behavior Change Techniques in Phase 2

Behavior Change Technique	Hypothesized Targeted Construct	Behavior Change Strategies for Control group	Behavior Change Strategies for Intervention Group
Modeling the behavior	Task self-efficacy	**Instruction on how to perform a behavior**: Participants practiced the RT exercises for four sessions with feedback on technique. **Demonstration of the behavior**: the personal trainer will modelled each RT exercise.	**Instruction on how to perform a behavior**: participants practiced the RT exercises for four sessions with feedback on technique. **Demonstration of the behavior:** the personal trainer will modelled each RT exercise.
Providing instructions on how to do the behavior	Self-efficacy	Participants received pdfs with written instructions on how to complete each exercise.	Participants received pdfs with written instructions on how to complete each exercise.
Goals setting	Behavioral expectations Coping planning Intention	**Goal setting:** participants were instructed to set the goal of achieving and maintaining RT two times per week. Participants do not revisit this goal.	**Goal setting:** participants were instructed to set the goal of achieving and maintaining RT two times per week. This was revisited each week.
Action planning	Behavioral expectations Coping planning Intention	N/A	. **Action planning** Participants planned when they would engage in RT
Barrier identification and problem solving	Behavioral expectations Coping planning Intention	N/A	Participants were prompted to list several barriers to and then ways to overcome them. Specific **coping plans** were formed based on established barriers.
Prompt practice	Intention	N/A	Participants received automated SMS reminders of their plan

Participants in the intervention group received four coaching sessions each separated by one week led by the PI. The PI assisted participants plan when they will be able to do their digital RT session, addressing action planning. Once the plan was made the time was added to the participants' digital calendar. In each coaching session, participants identified any barriers that may interfere with their scheduled times and make plans to work around these barriers. The coaching sessions lasted 15 to 20 minutes. Participants were also asked to add the planned RT session into any other electronic scheduling system. They were asked when they would like a reminder sent out to them via text message. Participants received a reminder for each scheduled RT session (2x/week). Coaching occurred on three additional sessions. To ensure that participants attended these coaching sessions appointments with follow-up reminders were sent via email and text message. Attendance was recorded and taken into account in the analysis. Synthesized procedures for Phase II are available in Table 21.

Table 21. Procedures for Phase II: Intervention

Session for Intervention	Procedures for Intervention	Session for Control	Procedures for Control
Week 2 Phase II	Participants received access to RTinHome.com.	Week 2 Phase II	Participants received access to RTinHome.com.
Weeks 2, 3,4,5 of Phase II	Completed video-based RT. No hands-on training [a].	Weeks 2, 3,4,5 of Phase II	Completed video-based RT. No hands-on training [a]
Week 2, 3, 4, 5 of Phase II	Participants met with the PI for a behavioral coaching session [b]	Week 3, 4, 5 of Phase II	N/A
Conclusion of Phase 2	Complete Questionnaires [c]	Conclusion of Phase 2	Complete Questionnaires [c]

[a] 30 min
[b] 5-15 min
[c] 10-15 min

Phase III: Four-Week Follow-Up

After the completion of Phase II, participants were instructed to do RT on their own by following the RT videos on RTinHome.com.

Measures

Validated measures, described below, were used to assess affective attitude (Courneya et al., 2004 α=0.82), task self-efficacy (Gao, Xiang, & Lee 2008 α=0.79), intentions (Plotnikoff et al., 2009 α=0.97), and behavioral expectations (Williams et al., 2015 α=0.925). The behavioral expectation questionnaire asked participants to rank the likelihood that they would engage in RT under certain circumstances (i.e. when tired). Participants were then asked if they had a plan for what to do under each of these circumstances (Yes/No) (Table 22). All participants received an email with a Qualtrics link to the surveys. Behavior was assessed at the conclusion of the Phase II and III with a modified Godin Leisure Time Questionnaire.

Affective Attitude

To measure affective attitude, participants rated their perceptions of engaging in RT on a six-point Likert scale with three questions (e.g., unenjoyable–enjoyable, boring–fun, unpleasant-pleasant) (Courneya, et al., 2004).

Self-Efficacy

To measure task self-efficacy participants rated their confidence to successfully accomplish several items on a scale from 0 (no confidence) to 100 (completely confident). The items included [1] I have the confidence in my ability to learn weight training well [2] I have confidence to perform weight training workouts on my own [3] I have confidence in my weight training performance [4] I have confidence in my ability to handle weight room equipment [5] I have confidence in my ability to handle weight room equipment and [6] I have all the knowledge needed to perform weigh training workouts very well.

Behavioral Intention

To measure behavioral intention, participants rated their intention to do RT by rating their agreement with four items on seven-point Likert scales. Participants were given the RT guidelines (2 times per week) and asked: [1] ''Based on the definition above, how motivated are you to meet the guidelines for strength training over the next 4 weeks? from 1 (extremely unmotivated) to 7 (extremely motivated), [2] ''How committed are you to meeting the guidelines for strength training over the next 4 weeks,'' from 1 (extremely uncommitted) to 7 (extremely committed), [3] ''How motivated are you to increase the amount of strength training that you are currently doing over the next 4 weeks?'' from 1 (extremely unmotivated) to 7 (extremely motivated) and, [4] ''I strongly intend to do everything I can to meet the Guidelines strength training over the next 4 weeks'' from 1 (extremely untrue) to 7 (extremely true) (Plotnikoff et al., 2009).

Behavioral Expectation and Coping Planning

For the *Behavioral Expectation* scale (Williams et al., 2015), participants rated their likelihood (0-100%) of engaging in RT in the context of 10 potential barriers (e.g. busy and short of time, have many work obligations, tired) (Williams et al., 2015). Coping planning was assessed by asking participants if they had plans for what to do if these barriers came up (Y/N).

Behavior

Behavior was assessed at two-time points; at the end of Phase II and Phase III. RT behavior was assessed with a modified version of the Godin Leisure Time Questionnaire (Plotnikoff et al., 2009). Plotnikoff et al. (2009) assessed days and time and created a sum score. However, because participants followed prerecorded videos, each with the same length, only days per week of RT behavior were assessed.

Demographics

Participants completed a questionnaire providing information on their age, sex, education level, self-reported weight and height, and their race and ethnicity.

TABLE 22. Questionnaires included in Study 1 Survey

Psychological variable	Description	Source	α
Affective attitude	Three questions assessed positive or negative feelings associated with RT.	Courneya et al. (2004)	0.82
Self-efficacy	Questions assessed participants confidence in their abilities to perform weight training workouts.	Gao et al. (2007)	0.84
Intentions	Four questions probed participants about their commitment and motivation to engage in RT.	Plotnikoff et al. (2009)	0.97
Behavioral expectation	Questions assessed participants confidence to overcome barriers to RT	Williams et al. (2015)	0.925
Coping planning	Questions asked if participants made plans in the face of specific barriers		

Analysis

Sample Size

For planning interventions, previous research has observed medium to large effect sizes of coping planning (φ =.37) when comparing planning conditions versus neutral controls (Carraro & Gaudreau, 2013). A power analysis was completed using G Power 3.1, using a medium to large effect size, revealed that 47 participants would be necessary to detect a medium effect (d = 0.37) as significant for the outcome in a repeated measures test where the alpha error probability set at 0.05 and power adjusted to 0.80. Previous RCTs which have compared groups have used 41 participants with three independent variables (Millen & Bray, 2009). Factoring in a potential 20% drop out, the study will aim to enroll 60 participants.

Analysis

Descriptive statistics (means ± standard deviation) were calculated for all constructs and RT behavior. The primary aim is to test whether an intervention group that receives enhanced

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coaching engages in more RT than a group that does not. Data will be analyzed using STATA. Significance for all statistical analyses was set at $\alpha \leq 0.05$. Losses to follow-up will be disclosed at both time points (end up supervised practice and end of follow-up).

Aim 1 Hypothesis and Analysis Plan

It was hypothesized that the intervention would produce significantly greater adherence to RT. We ran a model in which baseline days of RT in the last month before the study was a predictor of RT at the end of Phase II and where RT at the end of Phase II was a predictor of RT at the end of Phase III. Group was a predictor of RT behavior at the end of Phase II and III.

Aim 2 Hypothesis and Analysis Plan

We hypothesized that (a) relative to participants in the control condition, participants in the intervention condition would show more positive changes in the targeted putative mediators – intention, behavioral expectations, and coping planning, during the four week program (b) change in the putative mediators would be predictive of RT behavior at the follow-up time point and (c) the relative effects of the intervention on RT behavior would occur through coping planning and behavioral expectations.

We tested the effects of treatment on changes in intention, self-efficacy, behavioral expectations and coping planning and the effects of changes in intention, self-efficacy, behavioral expectations, and coping planning on RT behavior. In the analyses, each mediator will be tested independently and will be coded with a change score. The treatment effects were estimated using a series of regression models to examine the potential mediating effects of behavioral expectations and coping planning.

Table. 23 Cochrane Collaboration's Tool for Assessing Bias

Bias domain	Source of bias	Support for judgement	Author's judgement
Selection bias	Random sequence generation	We will use a random numbers generator with 1 and 2 options. One will represent the Control group and two will represent the Intervention group.	Low
	Allocation concealment	We will not know what group each participant will be in until the random numbers generator is used.	Low
Performance bias	Blinding of participants and personnel	The PI will be conducting the coaching sessions; therefore, the PI will know what group each participant is in. The PI will never be in attendance at any digital RT sessions or at. The PI will not assess attendance until the conclusion of Phase III. Personal trainers will not work with the participants after Phase I and will be asked to not contact them.	Medium
Detection bias	Blinding of outcome assessment	Participants will be encouraged to not discuss the details of the study with any other participants. We realize that some participants may know other participants in the study and may speak to them.

The PI, who is doing the behavioral coaching, will know what group each participant is in. | Medium |
| Attrition bias | Incomplete outcome data | Differences between dropouts in each group will be reported and analyzed. Participant analysis at each phase (end of supervised session vs follow-up) will report attrition rates. | Low |
| Reporting bias | Selective reporting | We will report differences for all measured variables and for all demographic and anthropometric variables. | Low |
| Other bias | | There will be recruitment bias, for example we are only recruiting from one campus.

Participants may also discuss the study with each other. | Medium |

Table 24. Treatment and Fidelity Tactics

Domain	Methods to Enhance RCT Design
Design	Digital RT intervention with training based on ACSM recommendations; sufficient power to detect treatment effects; validated measures; trainers blinded to treatment condition of the participants; clear protocol length; behavioral intervention based on HAPA.
Training providers	Trainers will have appropriate certifications and social skills; trainers will undergo a training procedure to ensure understanding of the program and how to coach through Zoom; ongoing feedback to trainers via weekly meeting with PI. Trainers will not contact participants outside of the two scheduled training sessions.
Delivery of digital RT content	All digital RT sessions can be found online. RT video content is self-guided, participants follow the routine with the instructor. The instructor in the video is not known to participants. The training video provides cues, as dose the RT educational pack participants receive.
Delivery of behavior change techniques	Behavior change techniques based on sound theoretical approach and previous research; enhanced coaching sessions utilize a semi-scripted outline. Behavior change techniques will be conducted over Zoom and SMS messaging. Behavior change techniques are reported via guidelines set by Michie et al. (2013)
Receipt of treatment	All participants will receive access to a website that provides training videos, explanatory digital manuals for each training routine, and RT health and education information. Participants will receive digital training via zoom that includes modeling of the RT exercises as well as corrective feedback. All participants can log training sessions into a training application.
Enactment of treatment	All participants complete training sessions in at their home; during guided RT RPE will be regulated; during guided RT participants will become familiarized with the training app. Once randomization has occurred participants will receive a collection of at home training videos to follow throughout phase 2 and 3. All RT video RT sessions can be found at

Table 25. Timeline

Study tasks	2020								2021			
	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Proposal	✔											
IRB approval		✔										
Recruitment of student trainers		✔										
Remote training of student trainers		✔	✔									
Remote recruitment			✔	✔	✔	✔	✔	✔	✔			
RCT			✔	✔	✔	✔	✔	✔	✔	✔	✔	
Data collection						✔	✔	✔	✔	✔	✔	
Data analysis											✔	✔
Write-up and dissemination												✔

CHAPTER 4

A HEALTH ACTION PROCESS APPROACH INTERVENTION FOR ADOPTING
RESISTANCE TRAINING IN ADULTS

Abstract

Introduction: There is little research to date that has been conducted testing theory-based interventions to increase resistance training. We assessed the relative efficacy of Health Action Process Approach (HAPA) based digital intervention for performing resistance training (RT). **Methods:** The RTinHome study was a three-phase study which recruited adults aged 18-35 not meeting the strength training recommendations. In Phase I, all participants received two Zoom based training sessions over a one-week period. In Phase II, participants were randomized to a no contract control or to a 4-week, HAPA based digital coaching intervention. In Phase III (follow-up) there was no contact with all enrolled participants for four weeks. Attitude and self-efficacy were assessed after the first training session in Phase I. Attitude, self-efficacy, coping planning, behavioral expectations, and intention were assessed at the end of Phase I, at the end of Phase II, and at the end of Phase III. A structural equation model was fit to each data collection point to test treatment effects on behavior. It was hypothesized that the intervention would have positive effects on behavior at the end of Phase II and III. **Results**: There were significant resistance training behavioral differences between the groups, favoring the intervention group, at the end of Phase II in adherence for both the previous week (last 7 days) (.50 SE=.24; p=0.040) and the previous four weeks (1.92 SE=.90; p=0.033) but not during Phase III. **Conclusion:** The

intervention had effects on RT behavior at the end of Phase II but group differences were no longer significant at the end of Phase III

Introduction

Resistance training (RT) is a unique exercise modality that requires specific knowledge, confidence, and equipment (Rhodes, Lubans, Karunamuni, Kennedy, & Plotnikoff, 2017). Resistance training reverses muscle loss, increases bone mineral density, reduces body fat and the risk of type 2 diabetes, improves cardiovascular health, resting blood pressure, blood lipid profiles, mental health, and can reverse aging factors (Westcott, 2012). The American College of Sports Medicine (ACSM) and the American Heart Association (AHA) recommend that adults perform exercises to strengthen their muscles for a minimum of two days per week (ACSM, 2009; WHO, 2020). According to the ACSM et al. (2009), muscle-strengthening activities may include a progressive weight-training program, weight bearing calisthenics, stair climbing, and similar resistance exercises that use the major muscle groups. Despite the established benefits, most adults are not meeting the resistance training guidelines (CDC). To increase the prevalence of RT participation, it is necessary to identify and understand the determinants of RT behavior and how they are to be targeted in a theory-based intervention. It has been reported that theory-based interventions are more effective in impacting behavior than non-theory-based interventions (Michie & Abraham, 2004), thus, behavioral interventions, based in theory, that promote strength training are needed.

The Health Action Process Approach (HAPA) is a theoretical model that has been utilized in physical activity research (Rhodes & Yao, 2015) incorporating several of these determinants including self-efficacy, intention, and coping planning. The HAPA is appealing as a theory to understand resistance training because it contains several constructs that align with the established psychological correlates of behavior, specifically a self-regulatory component

which mediates the intention-behavior relationship. However, to date it has only been used in one resistance training study (Paech & Lippke, 2017).

Resistance training studies have examined relationships between behavior and psychological variables using Social Cognitive Theory (Rhodes et al., 2016; Lubans et al. 2012; Millen & Bray, 2009; Neupert, Lachman, & Whitborne, 2009; Gao et al., 2007, 2008) the Theory of Planned Behavior (Bryan & Rocheleau, 2002; Courneya et al., 2004; Dean et al., 2006; Forbes et al., 2015; Plotnikoff et al., 2008; Rhodes et al., 2007), the Transtheoretical Model of Behavior Change (Cardinal & Kosma, 2004; Cardinal et al., 2005; Fetherman et al., 2011; Harada et al. 2008; Ott et al., 2004) and the Health Action Process Approach (HAPA) (Paech & Lipke, 2017). Some of the identified determinants of resistance training have included attitudes, perceived behavioral control (PBC), outcome expectations, self-efficacy, intentions, and self-regulation (Rhodes et al., 2017).

Self-efficacy refers to beliefs about one's capabilities to learn and/or perform specific behaviors (Bandura, 2004). The stronger the sense of self-efficacy, the more challenging the goals are that people set for themselves (Bandura, 2004). Attitudes describe the degree to which a person has a favorable or unfavorable appraisal of a behavior (Ajzen, 1991). Intentions are an indication of how much effort a person is willing to exert in order to engage in a behavior. Intentions describe all the motivational factors that influence behavior (Ajzen, 1991). Self-regulation encompasses the goals people set for themselves and the plans and strategies for realizing them, and the modification of facilitators and barriers to achieve the changes people seek to make (Bandura, 1991, 2004). Coping planning involves anticipating personal risk situations and planning coping responses in detail (Sniehotta, Schwarzer, Scholz, Schuz, 2005). Behavioral expectation is the extent to which one expects that they will engage in RT given

potential barriers (Williams et al., 2016). Self-efficacy, affective attitude, intention, behavioral

expectations, and coping planning were assessed in this study.

Theory-based behavior change techniques have been delivered face-to-face, through

print, video, text message, and some combination of these delivery modalities. To the authors

knowledge, no RT RCT has examined an entirely remote coaching method of delivering

behavior change techniques (BCT's). However, eHealth and telecoaching may provide insight on

the feasibility of a digitally based RT intervention. eHealth interventions can reach more people

than traditional face-to-face interventions in a time-efficient way (Eng, 2001). There is evidence

for the efficacy of telephone-delivered physical activity interventions (Goode, Reeves, & Eakin,

2012). The use of SMS, or text message, reminder prompts has been shown to have positive

effects on physical activity behavior (Gell, Grover, Savard, & Dittus, 2020). Pairing SMS

reminders with action planning may be an effective way to boost the effect of action planning

(Prestwich, Perugini, & Hurling, 2009). Thus, an internet-based coaching intervention conducted

through digital platforms such as Zoom combined with automated reminders would be ideal to

coach RT and provide participants with behavior change strategies.

Purpose and Hypotheses

The purpose of the present study was to test the efficacy of remote RT and behavioral

coaching intervention based on HAPA to an RT coaching only intervention. A secondary

purpose of the study was to examine the effects of the intervention on the psychological

constructs that are proposed to be related to strength training behavior. It is hypothesized that

participants who receive the behavioral coaching intervention will engage in significantly more

days of RT than those who do not receive the intervention (H_1) and at follow up (H_2). It is also

hypothesized that compared to the control group, participants in the intervention group will

report greater improvements in the targeted psychological constructs self-efficacy, intention,

coping planning, and behavioral expectations at all measurement time points after the intervention has been applied (H_3). Lastly, it was hypothesized that participants receiving the intervention will show significant improvements in the targeted constructs from preintervention to post intervention. We hypothesize the control group will show no changes in self-efficacy, intention, coping planning, and behavioral expectations (H_4).

Methods

The RTinHome study was approved by the IRB at the University of Massachusetts Boston. The study involved three phases: guided training (one week), intervention (weeks 1-5), and no contact (weeks 5-9) and four assessment points: post first training session, post second training session, upon the completion of Phase II and upon the completion of Phase III. Self-efficacy and attitude were the only constructs which were measured at all four points. We assessed these constructs after a single session so that participant ratings were based on experience. Intention, behavioral expectations, and coping planning were measured after the second training session and, after Phase II and Phase III.

Setting

Recruitment for this study occurred digitally but targeted University students at the University of Massachusetts Boston. All strength training and coaching sessions occurred over Zoom.

Participants and enrollment

Enrollment occurred on a rolling basis beginning in October 2020 and continuing until December 2020. Recruitment was done via campus wide emails with the tagline "in home personal training study". Participants were adults between the ages of 18 and 35 who were not currently meeting the CDC recommendations of two times per week for strength training. Exclusion criteria included medical conditions that would interfere with strength training or currently meeting the strength training guidelines. A total of 61 participants were randomized to

a control group or an intervention group. Participants in each group received two dumbbells and a strength training elastic band, two Zoom based, individual, personal training sessions, and access to a website with the same pre-recorded strength training videos.

Figure 1. Participant Flow Diagram
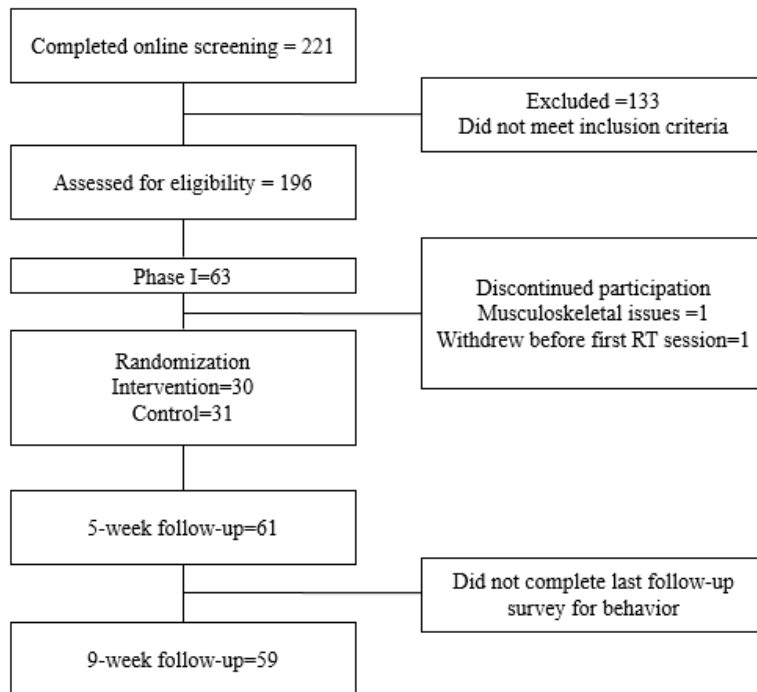
Phase I: Resistance training intervention

The home-based digital RT program consisted of free weight, body weight, and band resisted movements which trained the full body. Prior to commencing the study, two assistants with certifications (NSCA-CPT) and personal training experience were trained by the PI to serve as the personal trainers for the study. Participants were assigned a trainer to work with for two sessions. Participants were matched with a trainer based on mutual availability. When working with the trainers, participants watched a recorded video that demonstrated the exercise while listening to verbal cues from the trainer. Participants then complete each exercise under the supervision of the trainer who provided corrective and encouraging feedback. Trainers also

provided options for regressions and progressions of each exercise. Participant conducted two

sets of each exercise. Sessions were conducted on non-consecutive days and lasted 30 to 40

minutes.

Phase II: Common Components and Randomization

To move to Phase II, participants needed to attend both guided digital RT sessions.

Participants were stratified by sex and randomized using a random numbers generator.

Regardless of group, all participants received a link to a website designed for this study

(www.RTinHome.com). The website included the following: RT guidelines, the health benefits

of RT, four videos of self-guided workout routines and detailed instructions and images on the

exercises that were completed in Phase I. The RT exercise options for Phase II of the program

were comprised of exercises participants learned in the guided sessions in Phase I. However, the

exercises were varied to form four different routines (Table 1).

Table 1. Resistance Training Routines

Circuit	Routine 1 Exercise Sets x Reps/Time	Routine 2 Exercise Sets x Reps/Time	Routine 3 Exercise Sets x Reps/Time	Routine 4 Exercise Sets x Reps/Time
1	Dumbbell squat 3x10 Dumbbell Curl 3x10 Dumbbell front raise 3x10	Overhead press 3x10 Dumbbell lunge 3x10 Bird dog row 3x10	Dumbbell lunge 3x10 Band row 3x10 Band curl 3x10	Band row 3x10 Shoulder taps 3x10 Overhead press 3x10
2	Squat hold 3x10 Overhead press 3x10 Dumbbell lunge 3x10	Skull crushers 3x10 Band row 3x10 Dumbbell squat 3x10	Dumbbell squat 3x10 Pulse squat 3x10 Overhead press 3x10	Dumbbell lunge 3x10 Plank 3x20 sec Dumbbell squat 3x10
3	Band row 3x10 Leg lowering 3x10 Plank 3x20 sec	Calf raises 3x10 Romanian deadlift 3x10 Push-up 3x10	Band press 3x10 Leg lowering 3x10 Mountain climbers 3x10	Skull crusher 3x10 Squat to press 3x10 Dumbbell curl 3x10

Along with the email which provided access to the website, participants in the *Control* group were encouraged engage in RT two times per week for the next eight weeks. At this point the control group received no further instruction from the study team. Participants randomized to the *Intervention* group, received a self-regulation-based intervention. Participants received four coaching sessions each separated by one week. Coaching sessions were led by the PI. The PI assisted participants in planning the two days and times that they would engage in strength training. Participants were told to put the date and time into the scheduling system that they were currently using (Google calendar, Outlook, paper journal). Participants were asked when they would prefer an automated text message reminder of their plan. Automated messages were set up after the coaching session using a commercially available website (EzTexting.com). In each

coaching session, participants identified barriers that may interfere with their scheduled times

and were guided by the coach to make plans to work around these barriers. The coaching

sessions lasted 5 to 15 minutes (see Table 2) and 98.3% of coaching sessions were attended.

Table 2. Procedures for Phase II

Session for Intervention	Procedures for Intervention	Session for Control	Procedures for Control
Week 2 Phase II	Participants receive access to website	Week 2 Phase II	Participants receive access to website
Weeks 2, 3,4,5 of Phase II	Complete video-based RT. No hands-on training [a].	Weeks 2, 3,4,5 of Phase II	Complete video-based RT. No hands-on training [a]
	Participants met weekly with the PI for a behavioral coaching session [b]		No further sessions
Conclusion of Phase 2	Complete Questionnaires [c]	Conclusion of Phase 2	Complete Questionnaires [c]

[a] 30 min
[b] 5-15 min
[c] 10-15 min

Phase III: Four-Week Follow-Up
      After the completion of Phase II, all participants were sent via email the next series of

questionnaires and instructed to do RT on their own two times per week for the next four weeks

by following the RT videos on the website. Follow-up surveys were sent four weeks after the end

of Phase II via Qualtrics.

Measures
      Validated measures were used to assess affective attitude (three questions, i.e. extremely

unenjoyable-extremely enjoyable) (Courneya et al., 2004 α=0.82), self-efficacy (eight questions,

i.e. "I have confidence in my ability to handle weight room equipment") (Gao, Xiang, & Lee

2008 α=0.79) intentions (four questions, i.e. "how motivated are you to meet the strength

training guidelines of two times per week for the next four weeks?") (Plotnikoff et al., 2009

α=0.97), and behavioral expectations (10 questions, i.e. "please rate how likely you are to resistance train when you are busy and short on time") (Williams et al., 2015 α=0.925). The behavioral expectation questionnaire asked participants to rank the likelihood that they would engage in RT under certain circumstances (i.e. when tired). Participants were then asked if they had a plan for what to do under each of these circumstances (Yes/No). Because these questionnaires have not been utilized with adults, we assessed internal consistency for self-efficacy (α=.83), affective attitude (α=.87), intention (α=.82), behavioral expectations (α-.90) and coping planning (α=.88). All participants received an email with a Qualtrics link to the surveys. Resistance training behavior was assessed at the conclusion of the Phase II and III with two questions from a modified Godin Leisure Time Questionnaire (Godin & Shephard, 1985; Lubans et al., 2012).

Analysis

In the first phase of the analysis, we tested the effects of the intervention on RT behavior at the end of Phase II and III (H^1 and H^2). We ran a structural equation model in which baseline days of RT in the last month before the study was a predictor of RT at post-intervention and where RT post-intervention was a predictor of RT at follow-up. In the second phase we tested the effects of the intervention on the psychological variables (H^3). A series of structural equation models were fit to each data collection point to test treatment effects on the psychological measures. Each model that tested treatment effects was composed of two parts, a measurement model, and a structural model. The measurement model specified the relationships between the manifest variables and latent constructs. The structural model defined the relationship between the constructs and treatment. Five separate models included manifest variables operationalized on five constructs, attitude, self-efficacy, intention, coping planning, and behavioral expectations (see Figure 2 for example). Full information maximum likelihood was used to estimate the

structural equation model. This estimation procedure allowed us to retain cases that otherwise would have been deleted for having missing values. By the end of Phase III there were two missing cases for RT behavior, eight for self-efficacy, six for attitude and intention, seven for behavioral expectations, and ten for coping planning.

Within group changes in the psychological variables were also assessed (H^4). First, a confirmatory factor analysis was used to define the latent constructs at each measurement point. For self-efficacy and affective attitude repeated measures occurred on four occasions (after the first training session, after the second training session, at the end of Phase II and at the end of Phase III). For intention, coping planning, and behavioral expectations, repeated measures occurred on three occasions (after the second training session, at the end of Phase II and at the end of Phase III). Therefore, we ran a series of mixed effect models with time nested within the individual for each group and for each latent variable.

Figure 2. Example of Structural and Measurement Model to Assess Group Effects
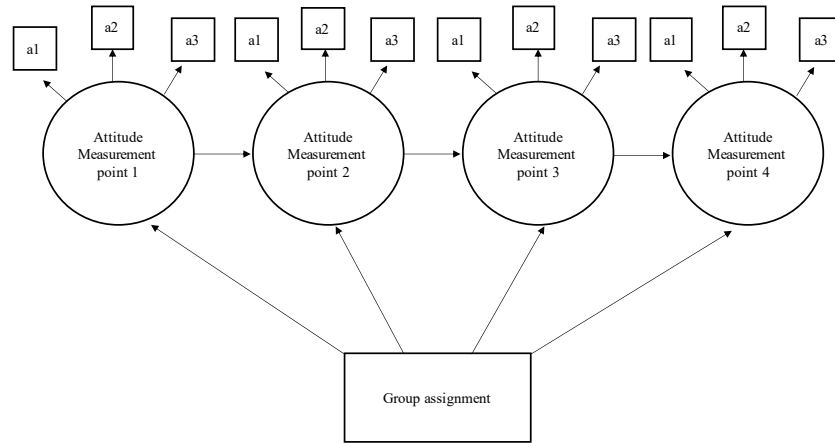
*a represents the attitude manifest questions

Results

Participants (n=61) self-reported a mean BMI of 26.0 (SD=5.8) with a range of 17.8-

46.1. Participants ranged in age from 18-35 with a mean age of 26.6 (SD=4.3). 86% of

participants were female and 14% were male. 17.5% of participants were Asian, 12.3% were

Black /African American, 15.8% were Hispanic or Latino, 50.9% were white and 3.5% chose not

to respond. Descriptive results can be found in Table 3.

Testing H1 and H2: Adherence to RT

Prior to enrolling in the study 83% of participants were not engaging in any RT and 17%

averaged 1 day per week. These data were used for baseline behavior. At the end of Phase II,

participants in the *intervention* reported 1.9 (SD= .92) RT sessions in the last week and

8.3(SD=3.1) in the last four weeks. Participants in the *control* group reported 1.3 (SD=.98) RT

sessions in the last week and 6.1 (SD= 3.8) in the last four weeks. At the end of Phase III

participants in the intervention group reported 1.2 (SD=1.6) RT sessions in the last week and 6.4

(SD=4.4) in the last four weeks. Participants in the control group reported 1.2 (SD=1.3) RT

sessions in the last week and 6.1 (SD= 4.6) in the last four weeks. Group was a predictor of RT

at post-intervention and follow-up. There were significant differences between the groups,

favoring the intervention group, at the end of the intervention period in adherence for both the

previous week (last 7 days) (.50 SE=.24; p=0.040) and the previous four weeks (1.92 SE=.90;

p=0.033) but not during the follow up time point. From postintervention to follow up the

intervention group significantly reduced the number of days in which they engaged in RT as

reported in days in the last week (p=.003) and days in the last four weeks (p=0.01) (Table 3).

Testing H₃: Differences in Psychological Variables

      There were significant treatment effects on self-efficacy (.77 SE=.27, p=0.004), intention

(.86 SE= .25 p=0.001), behavioral expectations (23.9 SE= 5.0 p=0.000), and coping planning

(.28 SE= .08 p=0.000) in the postintervention period favoring the intervention group. At the

follow-up time point there were no significant differences between the groups on self-efficacy,

intention, behavioral expectations, and coping planning.

Testing H₄: Changes in Psychological Variables

      There were no significant changes in *attitude* at any time point for the control group and

intervention group. There was a significance increase in *self-efficacy* from after the first personal

training session to the end of Phase II for the intervention group (.31 SE=.13, p=0.020). There

were marginally significant reductions in *self-efficacy* for the control group from after the first

personal training session to the end of Phase II (-.32 SE= .17 p=0.066). There was a significant

increase in *behavioral expectations* from after the second personal training session to the end of

Phase II for the intervention group (.45 SE=.16, p=0.004). There was a significant reduction in

behavioral expectations for the control group from after the second personal training session to

the end of the Phase II (-.43±.13 p=0.001). There was a marginally significant increase in

intention from after the second personal training session to the end of the Phase II (.27 SE= .14 p=0.059) and a significant reduction in intention from the end of Phase II to the end of Phase III for the intervention group (-.30 SE=.15 p=.0.042). There were no significant changes in *intention* for the control group. There was a significant reduction in *coping planning* from after the second personal training session to the end of the Phase II (-.43 SE= .12 p=0.000) and from after the second personal training session to the end of Phase III (-.25 SE= .12 p=0.046) for the control group. There was a significant increase in *coping planning* from after the second personal training session to the end of Phase II for the intervention group (p=.46 SE=.20 p=0.022) (see Table 3).

Table 3. Behavior and Psychological Measures

	Intervention Group				Control Group			
	Post first training session	End of Phase I	End of Phase II	End of Phase III	Post first training session	End of Phase I	End of Phase II	End of Phase III
	M SD	M SD	M SD	M SD	M SD	M SD	M SD	M SD
Variable								
Affective attitude[a]	6.6 (1.4)	6.9 (1.3)	6.6 (1.4)	6.5 (1.7)	6.6 (1.6)	6.7(1.4)	6.3(1.6)	5.7(2.0)
Self-efficacy[b]	7.3(1.3)	7.7(1.2)	7.7(1.0)*	7.0(1.9)	7.0(1.4)	7.1(1.4)	6.0(2.3)	5.9(2.7)
Intention[c]	N/A	6.7(.78)	6.6(1.0)	5.1(1.9)*	N/A	6.4(1.2)	5.3(1.6)	4.7(2.1)
Behavioral Expectation[d]	N/A	56.6(22.1)	67.8(22.3)*	55.2(29.1)	N/A	58.6(16.0)	49.0(23.3)*	46.6(29.6)
Planning[e]	N/A	3.6(3.6)	6.7(3.1)*	4.9(4.0)	N/A	3.4(3.0)	3.2(3.5)*	2.8(3.9)*
RT Behavior (d/week)	N/A	N/A	1.9(.92)	1.2(1.1)	N/A	N/A	1.3(.98)	1.2(1.3)
RT Behavior (d/month)	N/A	N/A	8.3(3.1)	6.4(4.3)	N/A	N/A	6.1(3.8)	6.1(4.5)

[a] Score is a mean of multiple items with scale 1-9
[b] Score is a mean of multiple items with a scale of 1-10
[c] Score is a mean of multiple items with a scale 1-7 and one on a 1-10 scale
[d] Score is a mean of multiple items with a scale 0-100
[e] Score is a sum of multiple items that can range from 1-10
For interpretation, scores represent average scores on the measured constructs, analysis was done with manifest variables loading onto latent constructs
*Significant differences within the group p<0.05

Discussion

The present study tested the effects of a HAPA-based self-regulation intervention on resistance training behavior and psychological variables known to be related to resistance training behavior. The intervention had transient effects. During Phase II, the intervention group reported significantly more more days of RT training in the previous week than the control group (0.6 more days). There were significant group effects on the targeted psychological constructs and the intervention group reported significant improvements in psychological constructs after the intervention.

Adherers to exercise programs have reported motivation, self-regulation, enjoyment, intrinsic motivation, and support as reasons for continued participations, whereas non adheres report a lack of these constructs (Eyon, Foad, Downey, Bowmer, & Mills, 2018; Huberty et al., 2008). The present study supports this notion. The RTinHome program had positive effects on intention, self-regulation, and provided support. However, once the intervention was removed these constructs returned to baseline levels and adherence to the program was reduced. Reductions in physical activity after the intervention have been observed in other studies. Rinaldi-Miles and colleagues (2019) observed a significant increase in step count followed by a return to baseline levels for participants in a planning intervention (Rinaldi-Miles, Das, Kakar, 2019). Accountability has been cited as contributing to adherence to physical activity (Eyon et al., 2018). Perhaps the reductions in RT behavior and psychological constructs were due to the removal of accountability that occurred during the coaching calls and more than four weeks of coaching is needed for a behavior to become habit.

To the authors knowledge, six original RT studies have attempted to target behavior change and specific psychological constructs including self-efficacy, intention, behavioral expectations, self-regulation, and outcome expectations (Fetherman et al., 2011, Plotnikoff et al.,

2010, Millen & Bray, 2009; Neupert et al., 2009, Ott et al., 2004, Winett et al., 2015). Of these studies, four had a comparison group (Fetherman et al., 2011, Lubans et al., 2012, Millen & Bray, 2009, Winett et al., 2015) and only one had a comparison group which received an intervention component (Winett et al., 2015). A comparison group is necessary to examine group differences. There may be natural reductions in psychological constructs over time. Without a comparison group it is not possible to determine intervention effects. In the present study, the comparison group was given the same resources as the intervention group. Thus, we were able to better understand the effects of the intervention on behavior and psychological constructs.

Interventions have had effects on the positive aspects of decisional balance (Fetherman et al., 2011, Ott et al., 2009), self-efficacy (Millen & Bray, 2009), behavioral expectations (Williams et al., 2016) and planning/self-regulation (Lubans et al., 2012; Williams et al., 2016) and have contributed to behavioral and strength differences favoring the intervention groups (Millen & Bray, 2009, Plotnikoff et al., 2010). This study adds to the resistance training literature by adding a non-wait list control, providing participants with equipment to engage in RT, and provides the intervention group with a multi-dose behavioral intervention.

The control condition in the present study closely mimics usual care in commercial fitness facilities where new members work with a trainer for a complimentary session and then left to use the equipment on their own with no further instruction. The control group in this study was given the same opportunity as the intervention group to engage in RT and work with a trainer to improve their capabilities. Therefore, lack of equipment can be ruled out as a confounding factor. It is worth noting that at the onset of the present study, none of the participants were meeting the strength training guidelines. Regardless of group, at the postintervention time point, 44% of participants were meeting the recommendation and at

follow-up 37% were meeting the recommendation compared to 0% meeting recommendations at baseline. In fact, at post intervention 86% of participants reported having done RT at least one time in the last week. At follow-up, 62% reported doing RT at least one time in the previous week. Simply providing participants with the necessary equipment and direction to do RT seemed to have positive impacts on behavior, though they were more pronounced in the intervention group. However, the issue of maintaining the RT behavior still remains.

Researchers have suggested that digital interventions should include multiple behavior change strategies which can include realistic goal setting, coaching, social support, action planning, and barrier identification (Sullivan & Lachman, 2017). Systematic review and meta-analysis suggest that compared to controls who do not receive SMS messages, interventions where participants received SMS messages led to small-to-medium sized effects on steps/day and MVPA. Combining SMS messages with other intervention components, as was done in this study, has been shown to lead to greater effect sizes on PA than those with fewer components (Smith, Duque, Huffman, Healy, Celano, 2020). Similar to the present study, interventions combining behavioral coaching which focused on barrier identification and problem solving with text message reminders has contributed to positive effects on MVPA. (Gell, Grover, Savard, Dittus, 2020). Because we did not test the independent effects of SMS reminders it is not possible to tease out the effects and future research should consider this.

Limitations
There are several limitations that should be addressed. The primary outcome of this study was days of resistance training. Yet, behavior was assessed subjectively making it subject to bias as well as memory recall issues. Because contact time with the PI was not matched between groups, is also difficult to say if it was the intervention that impacted behavior or if it was contact time. Furthermore, because of the use of multiple behavior change techniques it is challenging to

say which technique impacted which construct. Next, the study duration was not long enough to make any definitive conclusions on behavior change maintenance. Future research should consider a longer intervention period and a longer follow-up period.

CHAPTER 5

PSYCHOLOGICAL MEDIATORS OF A HEALTH ACTION PROCESS APPROACH BASED
RESISTANCE TRAINING INTERVENTION FOR ADULTS

Abstract

Introduction: Few individuals achieve the recommended amount of resistance training. Interventions that seek to enhance resistance training behavior should examine the mechanisms through which these interventions exert their effects. Mediation is one way to determine if an intervention changes behavior through its effect on cognitive variables. The present study is an analysis of the mechanisms of behavior change for a 9-week in home resistance training study with a 4-week intervention period. **Methods:** Participants (n=61) completed a three-phase intervention. All participants received two Zoom based personal training sessions, a pair of dumbbells, a resistance training band, and a website which hosted training videos. After two personal training sessions (Phase I) participants were randomized to either an intervention or control condition. Participants in the intervention condition received four weekly Zoom based coaching calls to discuss barriers and solutions to RT participants. Participants planned the date and time that they would engage in RT and received an SMS reminder at the time of their choosing (Phase II). Behavior was assessed at the end of the intervention period and then again after a four week follow up (Phase III). Self-efficacy, attitude, intention, behavioral expectations, and coping planning were assessed in all phases. A predictive model was examined using structural equation modeling. A mediation analysis was conducted to examine if the intervention had indirect effects on behavior through changes in any of the measured psychological variables. **Results:** From Phase I to Phase II the intervention had significant effects on self-efficacy (.68 SE

=.26), intention (.77 SE=.27), behavioral expectations (19.7 SE=5.3), and coping planning (.43 SE.13). Changes in self-efficacy (2.07 SE=0.83) and intention (3.0 SE=.61) had significant effects on RT behavior at the end of Phase II. In a multiple mediation model, intention mediated the effects of the intervention in Phase II (2.64 SE=.83). In the predictive model, intention at the end of Phase II predicted behavior at the end of Phase III (1.9 SE=.48). **Conclusion:** These findings suggest that intention is a predictor of behavior and that changes in intention may also contribute to changes in behavior. Therefore, techniques that target behavioral intention may be appropriate for in-home strength training interventions in adults.

Introduction

Recommendations by prominent health organizations have begun to include recommendations for resistance training in addition to aerobic physical activity (US Department of Health and Human Services, 2018, WHO, 2020). It has been well established that resistance training (RT) is a form of exercise that provides numerous health benefits (Westcott, 2012). RT increases bone mineral density, reduces body fat and the risk of type 2 diabetes, improves cardiovascular health, resting blood pressure, blood lipid profiles, mental health (Westcott, 2012). Despite these benefits, the percent of the population that engages in resistance training is low (CDC, 2017). The percent of adults meeting the resistance training guidelines (30.5%; CDC, 2017) is also significantly less than those meeting the 150 minutes of aerobic exercise guideline (50.3%; CDC, 2017).

There is a paucity of research on the psychological determinants of resistance training participation. Beyond the limited number of correlational or longitudinal studies examining the relationships between psychosocial variables and resistance training there are very few RCTs that have attempted to intervene on psychological determinants (Williams et al., 2016; Lubans et

al., 2012; Millen & Bray, 2009). With the limited number of RCTs it is challenging to determine what the best methods are to change these variables and the effects of enhancing these constructs on resistance training behavior.

A review of physical activity interventions suggests small effect sizes with heterogeneous outcomes. Thus, there is need to understand why an intervention may be successful (Rhodes, Janssen, Bredin, Warburton, Bauman, 2017). To enhance the percent of people meeting the strength training guidelines it is important to produce efficacious interventions. Theory based interventions are designed to intervene on the behavioral goal through intermediate constructs, or behavioral mediators. To achieve the goal of engaging in RT, psychological mediators of behavior must be targeted. Interventions must assess whether the intervention produced positive effects and understand how the proposed psychological variables mediate the effects of interventions on behavior. Mediation is one way to determine if an intervention impacts behavior through its impact on cognitive variables, these cognitive variables would they be considered mediators of the behavior change (Nigg, Borrelli, Maddock, & Dishman, 2008). Research has supported intentions, action planning, and self-efficacy as being important predictors of moderate and vigorous physical activity (MVPA) (Howlett, Schulz, Trivedi, Troop, & Chater, 2019). Similar constructs are related to RT behavior. Rhodes et al. (2017) found that attitude, perceived behavioral control (PBC), outcome expectations, self-efficacy, intentions, and self-regulation are correlates of resistance training behavior (Rhodes et al., 2017). However, only, two RT studies have conducted mediation test. Williams et al. (2016) observed that changes in behavioral expectations and self-regulation were significant mediators of RT behavior (Williams et al., 2016). Lubans et al., (2012) also found that self-regulation was a significant mediator of

RT behavior. These two studies suggest that self-regulation and behavioral expectations are important targets for RT interventions (Lubans et al., 2012; Williams et al., 2016).

Theory offers a descriptive system and direction for which psychological determinants should be targeted with behavior change techniques. The Health Action Process Approach (HAPA) is a theoretical model that has been utilized in physical activity research (Rhodes & Yao, 2015). However, to date it has only been used in one longitudinal resistance training study (Paech & Lippke, 2017). Despite, including a self-regulation component, no resistance training RCT has utilized the HAPA. The HAPA is appealing as a theory to understand resistance training because it holds many of the established psychological correlates of behavior, specifically the self-regulatory component which may mediate the intention-behavior relationship (Schwarzer, 2016).

Behavior Change and the Health Action Process Approach
Theory explains how an intervention may work and describes why a causal link between behavior change techniques and behavior change exist (Kok, 2016). Targeted behavioral determinants must be predictive of behavior and there must be a match between behavior change techniques and the determinants which are related to behavior (Kok, 2016). For example, it needs to be established that self-efficacy has a connection to behavior and the technique used (i.e. guided practice). In conjunction with the reviewed evidence on resistance training correlates (Rhodes et al., 2017) and the systematic review on intention translation theories (Rhodes & Yao, 2015), the constructs of task self-efficacy, outcome expectations, attitudes, intentions, maintenance self-efficacy or confidence to overcome barriers, and planning to overcome barriers would be useful in a conceptual model to explain resistance training behavior. Although, in the broader physical activity research, no one construct has been deemed the crucial driver of mediated effects on behavior (Rhodes, Boudreau, Josefsson, & Ivarsson, 2020).

The HAPA presents a mediator model that allows for the prediction of behavior and explains the assumed causal mechanisms of behavior change. In the HAPA, pre-intention constructs (outcome expectations, self-efficacy, risk perception) predict intention and intention is translated into action with self-regulation strategies such as action planning and coping planning (Schwarzer, 2016). Different research questions may employee more parsimonious models of the HAPA (Schwarzer, 2016). Because of the flexibility of this model to include certain constructs (i.e. affective attitude, behavioral expectation) the HAPA is a viable model for explaining resistance training behavior. It has been recommended that researchers and individuals who wish to translate physical activity interventions into practice utilize existing taxonomy to specify behavior change intervention components (Michie, Ashford, Sniehotta, Dombrowski, Bishop, & French, 2011). If targeted determinants of behavior have been identified, behavior change techniques (BCTs) should map onto said determinant. For example, if an intervention seeks to enhance self-regulation, self-efficacy, and intention, techniques that are purported to change these constructs should be utilized (Kok 2016). The use of multiple behavior change techniques, such as action planning and coping planning, which target post intentional constructs has been shown to be useful in promoting MVPA (Schroe et al., 2020). We provide an a priori specification of techniques and targeted constructs in Table 1. Based on behavior change taxonomy work (Kok, 2016, Michie et al. 2011), we report the use of the following techniques; goal setting (behavior), action planning, barrier identification and problem solving, prompting review of behavior goals, providing instructions on how to do the behavior, modeling/demonstrate the behavior, and prompting practice (Kok, 2016, Michie et al., 2011) (See Table 1 for how BCT's map onto targeted HAPA constructs). We combined several

techniques because the use of multiple behavior change techniques result in better outcomes than singular behavior change techniques (Rhodes, Janssen, Bredin, Warburton, Bauman, 2017).

The Present Study

The present study is a secondary analysis of the Resistance Training in Home (RTinHome) study. The purpose is to examine the HAPA constructs in predicting resistance training behavior in healthy young adult novices. Intervention studies benefit from adequately describing the content of behavior change techniques as well as their implementation (Hoffman, Glasziou, Boutron, 2014). The TIDieR checklist, which is used to describe components of the intervention necessary for replication, was followed (Hoffman et al., 2014). In the primary analysis we tested the effects of the intervention on changes in the targeted mediators. The RTinHome study was the first known randomized controlled trial that promoted RT in an entirely digital format. Utilizing electronic, or eHealth interventions, is a viable strategy to promote physical activity behavior change (Eng, 2001). These types of interventions can remove barriers to participation, have enhanced reach, and lower cost. Behavior change techniques (BCT's) are utilized to target the specified mediators of behavior and can be delivered through a digital format.

The goal of the present study was to first test the predictive validity of a model based on the HAPA from post intervention to follow up. We predicted that attitude and self-efficacy would predict intention, that intention would predict coping planning, and that coping planning would predict behavior (H_1). Mediator analyses can provide insight on intervention effects on the targeted psychological constructs, the predictive validity of changes in the psychological constructs on changes in behavior and provide an understand of how the intervention exerted its effects (Williams et al., 2016). An action theory test examines intervention effects on the proposed mediator. Conceptual theory test examines whether changes in the mediator had an

effect on the outcome variable (RT behavior). Simultaneously running action and conceptual

theory test can help to assess the extent to which the effects of the intervention were mediated by

the proposed mechanisms to change RT (Rhodes & Pfaeffli, 2010).

In a mediator analysis, mediation is assumed when the indirect path (Path ab; see Figure

2) is significant (Rucker, Preacher, Tormala, & Petty, 2011). Therefore, we sought to examine

the mediators of the RTinHome intervention. Self-regulation has promise as a mediator of

physical activity behavior change (Rhodes & Pfaeffli, 2010) and has been shown to mediate RT

behavior change (Lubans et al., 2012). Therefore, it was hypothesized that changes in coping

planning along with intention from the pre intervention period to post intervention period (weeks

1-weeks 5) would be predictive of behavior change (baseline to week 5). The same hypothesis

was made for post intervention to follow-up (weeks 5- weeks 9) (H_2 and H_3).

Figure 1. Proposed Model for Predicting Days of RT Based on the HAPA
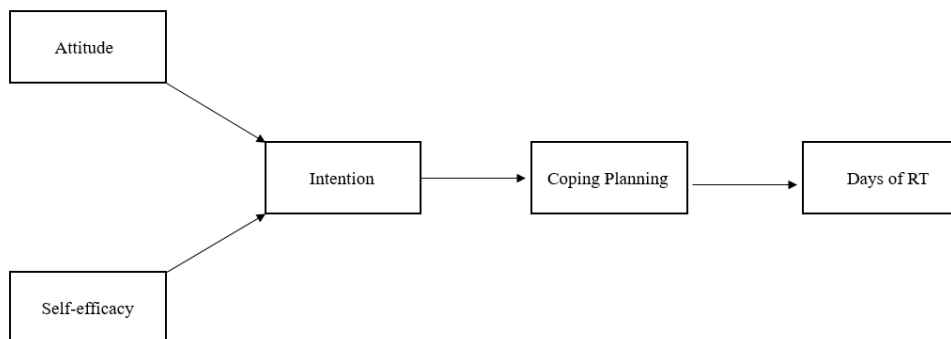
Figure 2. Proposed Mediator Model
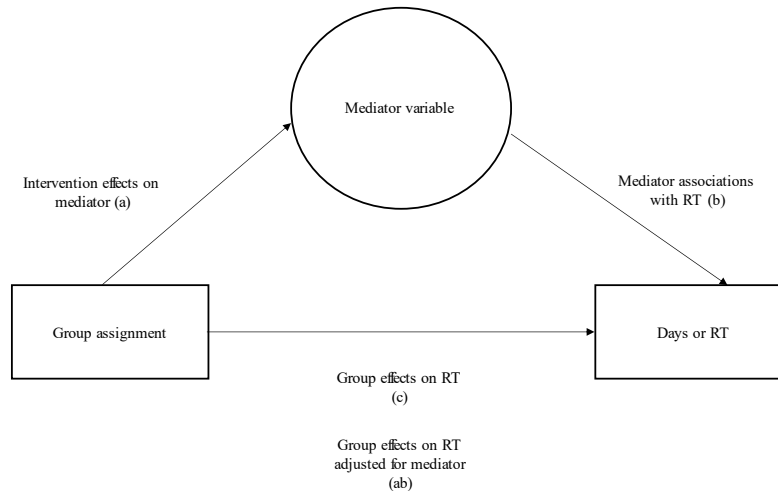
Methods

Participants

Participants were recruited via campus wide emails at the University of Massachusetts

Boston. Potential participants responded by completing a secure online questionnaire through

Qualtrics. Participants were contacted by the PI to confirm eligibility. Once eligibility was

confirmed, participants consented over the phone and were emailed to schedule their first session

with a training over Zoom. Participant eligibility included adults between the ages of 18 and 35

years who were not meeting the CDC recommendations of 2 days per week. Exclusion criteria

included medical conditions that would interfere with strength training or currently meeting the

strength training guidelines. As reported elsewhere, participants reported an average BMI of

26.0 (SD=5.8) with a range of 17.8-46.1. Participants ranged in age from 18-35 with an average

age of 26.6 (SD=4.3). 86% of participants were female. 17.5% of participants were Asian, 3.5%

were Black Caribbean, 8.8% were African American, 15.8% were Hispanic or Latino, 50.9%

were white and 3.5% chose not to respond (Kompf et al., under review). A total of 61

participants were randomized to a control group or an intervention group based on the HAPA.

Figure 3. Participant Flow Chart (Kompf et al., under review)
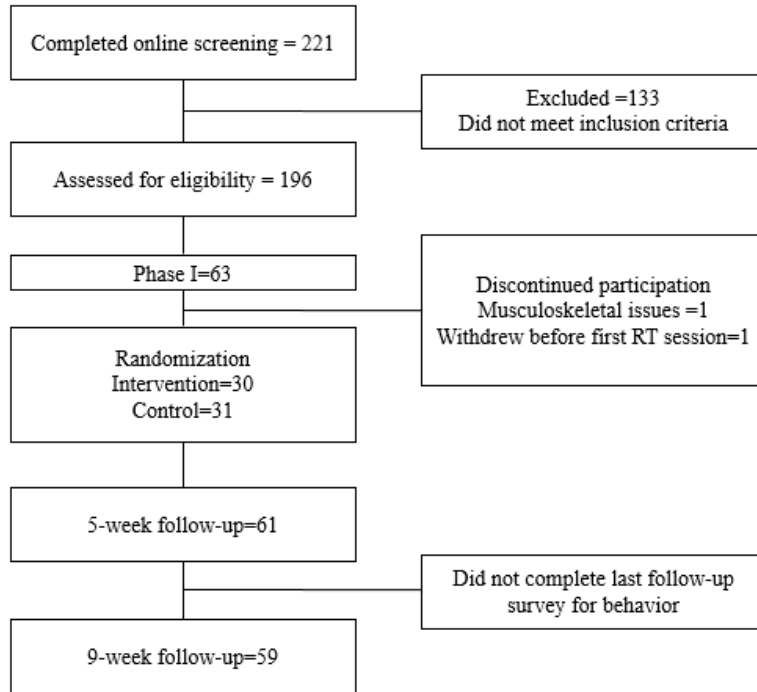
Intervention and Study Design

The present study analyzed the mechanisms through which the RTinHome study, a 9

week in home resistance training study, exerted its effects on behavior. All participants received

two Zoom based in home personal training sessions with a trained and certified personal trainer.

Personal training sessions lasted approximately 30 minutes and occurred on non-consecutive

days. Following the two training sessions participants were randomized to the control group or to

the behavioral coaching group. All participants received a link to the RTinHome website which

provided links to four training routines, instructional PDFs, RT guidelines and health benefits.

Participants in the intervention group met with the PI over Zoom on four separate

occasions spaced out by one week. In these coaching sessions participants planned the date and

time that they would do strength training and informed the PI as to when they would prefer to receive an automated text message reminder of their plan. This study used a text messaging Web site (EzTexting.com) which automated the timing of delivery of the messages. Intervention group participants received eight text messages over four weeks. Messages prompted participants to engage in RT (Hi [name], here is your reminder for your scheduled strength training today). Participants in the control group did not receive text messages. In the Zoom coaching sessions, participants also identified any barriers that may get in the way of their plan and collaborated with the PI to discuss potential solutions (Table 1). Sessions lasted 5-15 minutes.

Self-efficacy and affective attitude were measured immediately after the first training session so that responses were based on experience. Following the second training session, self-efficacy and affective attitude were measured again along with intention, behavioral expectations, and coping planning. Four weeks after randomization these constructs were measured again. Additionally, behavior was assessed. Eight weeks after randomization affective attitude, self-efficacy, intention, coping planning, behavioral expectation, and days of RT were assessed for the last time. The primary analysis from the RTinHome study demonstrated differences in behavior post intervention but not at follow-up. Specifically, the control group engaged in 6.1 (SD=3.8) days of strength training during weeks 1-5 and 6.1 (SD=4.4) days during the follow up period (weeks 5-9) and the intervention group engaged in 8.2 (SD=3.1) and 6.4 (SD=4.3) days during the same time periods (Kompf et al., under review). In this article, we examine the cognitive mediation processes that may be responsible for behavior change. Table 1 describes the behavior change techniques used as well as the hypothesized psychological construct that was targeted.

Table 1. Summary of Behavior Change Techniques

Hypothesized Targeted Construct	Behavior Change Strategies for Control group	Behavior Change Strategies for Intervention Group
Self-efficacy	**Instruction on how to perform a behavior**: participants will practice the RT exercises for four sessions with feedback on technique. **Demonstration of the behavior:** the personal trainer will model each RT exercise	**Instruction on how to perform a behavior**: participants will practice the RT exercises for four sessions with feedback on technique. **Demonstration of the behavior:** the personal trainer will model each RT exercise
Self-efficacy	Participants receive pdfs with written instructions on how to complete each exercise	Participants receive pdfs with written instructions on how to complete each exercise
Behavioral expectations Coping planning Intention	**Goal setting:** participants will be instructed to set the goal of achieving and maintaining RT two times per week. Participants do not revisit this goal.	**Goal setting:** participants will be instructed to set the goal of achieving and maintaining RT two times per week and will revisit this goal each week.
Behavioral expectations Coping planning Intention	N/A	. **Action planning** of when the participant will engage in RT Text message reminders of planned times to come in.
Behavioral expectations Coping planning Intention	N/A	Participants will be prompted to list several barriers to and then ways to overcome them. Specific **coping plans** will be formed based on established barriers.
Intention	N/A	Participants receive automated SMS reminders of their plan

Health Action Process Approach Measures

   Validated questionnaires assessed *affective attitude* (Courneya et al., 2004 α=0.82), *self-efficacy* (Gao, Xiang, & Lee 2008 α=.79), and *intentions* (Plotnikoff et al., 2009 α=0.97). Attitudes describe the degree to which a person has a favorable or unfavorable appraisal of a behavior (Ajzen, 1991). Affective attitude refers to beliefs about the expected affective feelings (i.e. unpleasant-pleasant). Self-efficacy refers to beliefs about one's capabilities to learn and/or perform specific behaviors (Bandura, 2004). Intentions are an indication of how much effort a person is willing to exert to engage in a behavior. Intentions describe all the motivational factors

that influence behavior (Ajzen, 1991). A behavioral intention or goal intention represents the end

of the deliberation process. It symbolizes one's commitment to action (Sheeran, Milne, Webb &

Gollwitzer, 2005). To assess coping planning, we first utilized a *behavioral expectation*

questionnaire (Williams et al., 2015 α=0.925). The behavioral expectation questionnaire asked

participants to rate the likelihood that they would engage in RT under certain circumstances (i.e.

when tired). To assess coping planning, participants were then asked if they had a plan for what

to do under each of these circumstances (Yes/No) with answers being dummy coded with 0

representing no and 1 representing yes. All participants received an email with a Qualtrics link to

the surveys. Resistance training behavior was assessed at the conclusion of the Phase II and III

with two questions from a modified Godin Leisure Time Questionnaire. Psychological constructs

were measured after the first in home RT session, after the second in home RT session in Phase

I, at the end of Phase II, and at the end of Phase III.

Statistical Analyses

To assess the proposed model a structural equation model was fit to determine if post

intervention measures could predict RT at follow-up. The model was composed of two parts, a

measurement model, and a structural model. The measurement model specified the relationships

between the measured variables and latent constructs. The structural model defined the

relationship between the constructs and RT behavior. To identify potential mediators of the

effects of the intervention we ran four univariate models for each time point (end of Phase II and

end of Phase III) on self-efficacy, intention, behavioral expectations, and coping planning. We

did not run an analysis for attitude since this construct was not targeted in the intervention,

therefore we did not hypothesize a change. Analysis from the primary study supports this

(Kompf et al., under review). In these analyses, each manifest variable for the mediator was

coded as a change score (i.e. intention change = intention Phase II- intention Phase I). Criterion

for mediation include significant intervention effects on the mediator, significant associations between the mediator and the dependent variable, RT, and a significant effect of the intervention on RT through the mediator (Murray, French, Kee, Gough, Tang, & Hunter, 2020). Therefore, effects were estimated using sem in which linear models tested the pathways between changes in the psychological variables and treatment (path a) and changes in the psychological variables and changes in behavior (path b). We also tested the direct effects of treatment on behavior (path c) and the indirect effects of treatment on behavior (path ab).

Full information maximum likelihood was used to estimate the structural equation model. This estimation procedure allowed us to retain cases that otherwise would have been deleted for having missing values (Enders & Bandalos, 2001). By the end of Phase III there were two missing cases for RT behavior, eight for self-efficacy, six for attitude and intention, seven for behavioral expectations, and ten for coping planning. Model fit was evaluated using root mean square error of approximation (RMSEA), and comparative fit index (CFI). Values exceeding 0.90 for the CFI and values less than 0.08 for RMSEA are indicative of acceptable fit of the model (Marsh, Hau, Wen, 2004). It was expected that due to the smaller sample size RMSEA would be inflated. Taasoobshirazi and Wang (2016) reported model rejection rates of over 30% based on RMSEA with sample sizes of 50 (Taasoobshirazi & Wang, 2016). Smaller sample sizes increase Type II error rates for the fit indexes (Taasoobshirazi & Wang, 2016). Analysis was conducted using STATA's sem command to calculate unstandardized regression coefficients.

Results
Path Analysis: Testing H$_1$
The HAPA based model was run with Phase II (week 5) variables predicting Phase III behavior (week 9). This model showed adequate but not good fit (RMSEA: 0.086, CFI: .910). In the first model, self-efficacy predicted intention (.96 SE=.27; p=0.000) and attitude predicted

intention (.22 SE=.09; p=0.010). Intention predicted coping planning (.22 SE=.047; p=0.000) and coping planning predicted days of RT (5.5 SE= 1.9; p=0.004). Intention (1.2 SE=.42; p=0.004) and self-efficacy (1.2 SE=.49; p-=.017) both had total effects on behavior. Therefore, we examined the indirect effects of these variables on behavior. Both self-efficacy (1.2 SE=.49; p= 0.017) and intention (1.2 SE=.42; p=0.004) had indirect effects on behavior. Consequently, we fit a model in which intention could also predict behavior, after which coping planning no longer predicted behavior, but intention did. Therefore, we removed coping planning from the analysis so there was a direct path only from intention to behavior and the model fit improved (see Table 2; Figure 5).

In the Best Fit Model, there were direct paths from self-efficacy (.83 SE=.20; p=0.000) and attitude (.27 SE=0.1; p=0.002) to intention and direct effects of intention on behavior (1.9 SE=.48; p=0.000). Self-efficacy (1.6 SE=.51; p=0.002) and attitude (.51 SE=.20; p=0.011) both had indirect effects on behavior through intention. Because past behavior is often considered a predictor of future behavior, we fit one last model where RT behavior at the end of Phase II could predict RT at the end of Phase III. When this was added to the model week 5 behavior predicted week 9 behavior (.71 SE=.16; p=0.000) and intention did not (RMSEA=0.058, CFI=.978).

Figure 4. Original Model (Model 1)
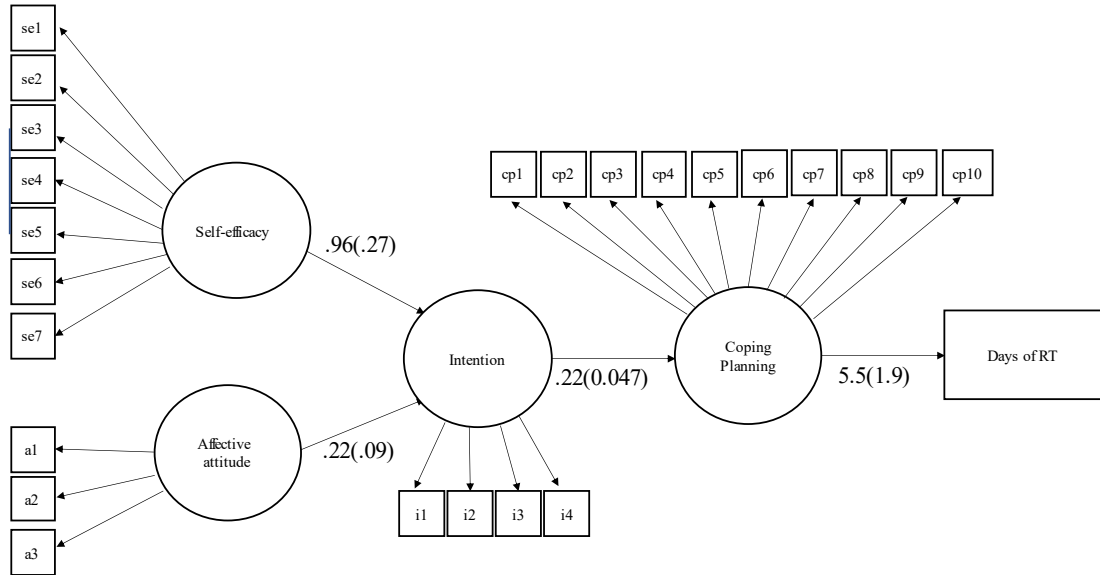
Figure 5. Best Fit Model (Model 3)
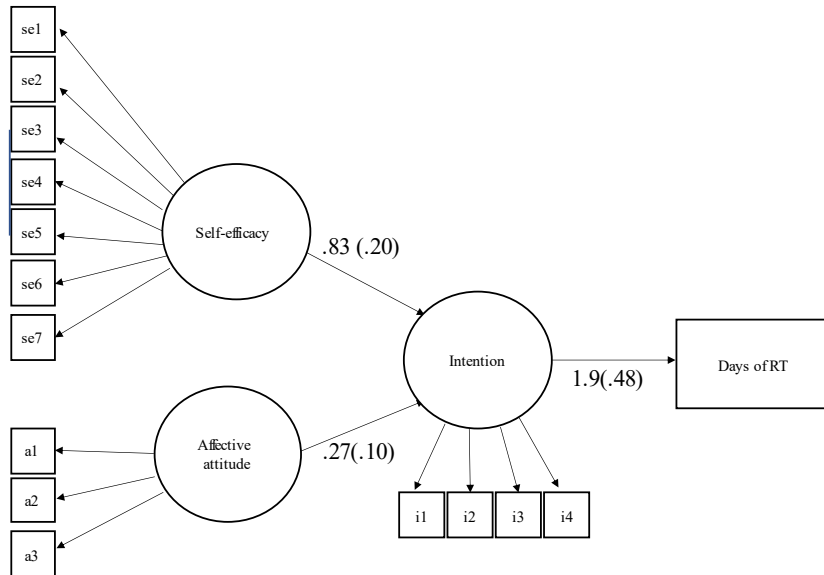
Table 2. Model Comparison

Parameter	Model 1 (without a path from intention to behavior)	Model 2 (with a path from intention to behavior)	Model 3 (coping planning removed, direct path from intention to behavior)
df	249	248	74
RMSEA	0.086	0.084	0.060
CFI	.910	.914	.979
AIC	3556	3552	3080
BIC	3770	3767	3209

Mediation Analysis: Testing H₂

We ran an analysis for each single mediator first. For the first measurement of behavior change at the end of week 5 there were direct effects of treatment (a path) on self-efficacy (.68 SE=.26; p=0.010), intention (.77 SE=.27; p=0.004), coping planning (.43 SE=.13; p=0.001) and behavioral expectations (19.7 SE=5.3; p=0.000). There were direct effects of self-efficacy (2.07 SE=0.83; p=0.013) and intention (3.0 SE=.61; p=0.000) on behavior change (b path). When self-efficacy was assessed, there were significant total effects for treatment on behavior (2.7 SE=.96; p=.005) (c path). Indirect effects of treatment through self-efficacy were significant as well (1.4 SE=.64; p=.030) (ab path). When intention was assessed, there was also significant total effects of treatment on behavior (2.79 SE=1.0; p=0.005) (c path). Indirect effects of treatment were also significant (2.32 SE=.83; p=0.005) (ab path).

We then ran a multiple mediator model with self-efficacy and intention. In the multiple mediator model, there were direct effects of treatment on self-efficacy (.67 SE=.26; p=0.010) and intention (.74 SE=.26; p=0.005). There were direct effects of intention on behavior (2.8 SE=.65; p=0.000). Total effects of treatment were significant (2.70 SE=.93; p=0.004) and the indirect effects of treatment on behavior through intention was significant (2.64 SE=.83; p=0.001).

At week 9 follow-up there were no direct effects of treatment on any psychological variable. There were direct effects of self-efficacy (2.4 SE=0.99; p=0.014), intention (1.27 SE=.31; p=0.000) and behavioral expectations (.07 SE=0.024; p=0.002) on behavior.

Discussion

This secondary analysis of a resistance training intervention examined the use of the HAPA model. Results from these analyses indicate intention was a proximal predictor of behavior and that changes in intention mediated the effects of the intervention. A common criticism of models such as the Theory of Planned Behavior which put intention as a proximal predictor of behavior is the modest relationship between intention and behavior (Sniehotta, 2009). However, intention is a variable that has strong predictive validity (Rhodes, Janssen, Bredin, Warburton, Bauman, 2017) and the present research supports this. Previous research using structural equation modeling has also identified direct paths from intention to behavior (Bryan & Rocheleau, 2002, Rhodes et al., 2007). Given that attitude and self-efficacy predicted intention, interventions may want to focus on enhancing self-efficacy and creating affectively pleasing (or at least minimizing unpleasantry) RT routines. According to the HAPA, the effects of intention are mediated through self-regulation constructs such as coping planning. While the first predictive model supports this, removing coping planning from the model improved fit as measured by RMSEA and CFI. This study adds to the RT literature and continues to support the importance of intention behavior relationship (Bryan & Rocheleau, 2002, Gao & Kosma, 2008; Paech & Lippke, 2017; Williams et al., 2016). From a practical perspective, it is important to examine the effects of enhanced intention on behavior.

While many constructs may be associated with a behavior, information on which variables should be targeted is obtained when an intervention and behavior change can be connected through changes in that variable (Rhodes, Boudreau, Josefsson, Ivarsson, 2020).

Webb and Sheeran (2006) observed that across health behaviors large changes in intention resulted in small changes in behavior (Webb & Sheeran, 2006). Effect sizes have been shown to be even smaller for physical activity (Rhodes & Dickau, 2012) and interventions fail to consistently show positive effects on intention (Rhodes et al., 2020). Rhodes and Dickau (2012) found that changes in intention did not result in meaningful changes in behavior (Rhodes & Dickau, 2012). However, our results suggest that changes in intention mediate the effects of the intervention at both times points.

At the end of Phase II, the intervention had positive effects on self-efficacy, intention, behavioral expectations, and coping planning. Changes in self-efficacy and intention predicted changes in behavior and both were mediators in the univariate analysis. Intention emerged as the only mediator in the multivariate analysis. This contrasts with two previous mediation analysis that suggest self-regulation, not intention, mediates the effects of the intervention (Lubans et al., 2012, Williams et al., 2016). It has been observed that approximately one-third of individuals who hold positive intentions to be physically active do not act on these intentions (Godin & Conner, 2008). On the other hand, only 4.5% of individuals with negative intentions to be physically active engage in physical activity. Thus, while intention is likely a necessary precondition for engaging in physical activity it may not adequately explain why a behavior such as physical activity would occur (Godin & Conner, 2008). RT research also suggests that intention may be a precondition for behavior to occur (Vallerand, Rhodes, Walker, & Courneya, 2016; Williams, Dunsiger, Davy, Kelleher, Marinik, & Winett, 2016; Rhodes et al., 2007), but most studies have been unable to explain a large portion of the variance in behavior with intention alone.

Therefore, it is interesting to note that although the intervention did have positive effects on coping planning, coping planning changes were not associated with changes in resistance training behavior. Coping planning changes may not have had an impact on behavior because barriers may have been low. This study was conducted during the COVID-19 pandemic where participants were encouraged to stay indoors. Combined with additional free time, limited activities to do, and ease of access to equipment, barriers may not have posed the same issue that they would have if participants were exercising in a fitness facility. For example, if participants needed to travel to a fitness facility or if they had more work or school commitments, they may have experienced more barriers.

Limitations

While a mediation analysis was conducted, the design of the study makes it impossible to separate the effects of each BCT. Distinct effects of SMS reminders, action planning, and coping planning cannot be tested. Therefore, it is unknown if one or any of these techniques was additive. A control group which received action planning and coping planning without SMS reminders could have directly tested the effects of reminders on behavior and the measured psychological constructs. While participants were randomized, we did not assess environmental factors such as home setting. It is possible that home space or the presence of roommates or other living partners may have an impact on behavior. Future research should consider living space as a variable to assess.

CHAPTER 6

CONCLUSION

The purpose of this study was to assess the effects of a self-regulation-based intervention on changes in targeted psychological constructs and resistance training behavior as well as the mediating effects of the intervention through changes in these constructs. Gauging the success of the present intervention can be examined in two ways. The first is to examine the differences between the control and intervention group. In this study there were meaningful differences between the groups post intervention. The second is to compare behavior prior to the intervention to behavior at post intervention and at follow-up. Providing participants who were not meeting the recommendations for muscle strengthening with training sessions, dumbbells, and a resistance tube had positive impacts on behavior, regardless of group assignment; however, the intervention group with digital coaching had greater changes in behavior and the psychological constructs. The addition of a self-regulation-based intervention provided further, yet temporary benefits. The simultaneous return to baseline as measured at the end of Phase III, in psychological constructs such as intention, self-efficacy, and planning and reduction in behavior in the intervention group gives insight into why the effects of the intervention were transient. Based on the enhanced behavior in both the control and intervention group, future studies must provide the opportunity to engage in RT and furnish participants with the skills to engage in RT. This is only the second RCT in which the control group was provided equipment and opportunity to participate in RT. Recent, in home research suggest that having equipment is

correlated with intention, planning, habit, and autonomous motivation and that having equipment predicts planning (Kaushal, Keither, Aguinaga, & Hagger, 2020).

Both the control and intervention group may be considered successful. Prior to the study, no participants were engaging in RT more than 1 time per week. Post intervention period, 77% of participants in the control group still reported 1 day of RT in the last seven days. Simply providing participants with the opportunity to engage in RT in their homes may have changed behavior. We found several notable results. The first is that the intervention had positive effects on behavior with participants in the intervention group averaging 0.6 more days per week of resistance training than the control group during Phase II. However, these effects were transient and at the follow-up time point there were no behavioral differences between the groups. The intervention also had positive effects on all of the targeted psychological variables including self-efficacy, intention, behavioral expectations, and coping planning. However, only changes in intention translated to changes in behavior.

At the time of the study, shelter-in-place and lockdown orders were in place to reduce the spread of COVID-19. Due to gym and recreation center closures, routines involving access to physical activity were disrupted for millions of Americans. For many, their only option to be physically active was in their own home. Physical inactivity is one of the most important public health issues of the 21st century (Blair, 2009). Physical activity interventions often yield small effect sizes (Rhodes, Janssen, Bredin, Warburton, Bauman, 2017). Therefore, it is imperative that iterations of behavioral interventions aimed to enhance physical activity improve. Research on how home-based routines can be advantageous to enabling RT is relevant both during and after the pandemic. This can only happen if the mechanisms through which interventions exert their effects is studied. Our study suggests that for 18-35 year old novices, changes in intention

brought about through a HAPA based intervention, contribute to changes in RT performed through a digital platform in one's home.

Intervention success must be weighed against cost. The cost for the present intervention included time, dumbbells, and resistance training bands. Dumbbells cost $24.00 per pair; a resistance tube cost $7.00. Student trainers volunteered approximately 1.5 hours per participant and the PI met with participants for approximately 45 minutes. If this time was valued at $30.00/hour this would equate to approximately $67.50 per person. Text cost approximately $0.05 each for a cost of $0.40 per participant. In total, the cost per participant in the intervention group was $98.90 and $76.00 in the control group. On average participants in the intervention group engaged in 2.5 more days of RT over the eight-week period. Therefore, the additional cost of $22.90 must be weighed against the fact that at the follow-up there were no group differences.

Digitally based interventions have the benefit of increasing access to strength training. Home based interventions may also be convenient and private (Plotnikoff et al. 2010). If an individual does not want to exercise in front of other people, in home exercise may remove this barrier. SMS message-based interventions are cheap and accessible mode of intervention, which may be important for underserved populations who do not have smartphones (Smith et al., 2020). In this study, SMS message cost constituted .04% of the cost ($0.05 per text).

To date, two RT studies have conducted mediation test. Williams et al. (2016) observed that changes in behavioral expectations and self-regulation were significant mediators of RT behavior (Williams et al., 2016). Lubans et al., (2012) also found that self-regulation was a significant mediator of RT behavior. These two studies suggested that self-regulation and behavioral expectations were important targets for RT interventions (Williams et al., 2016). However, the current study did not support this. Rather, changes in intention, brought about by

the intervention contributed to changes in RT behavior. It is plausible that due to COVID-19, participants were urged to stay indoors and may have had more free time or at least experienced less barriers to exercise. If barriers were less present, participants may have been able to act on their intentions without needing to apply self-regulatory techniques. This draws attention to the fact that it is important to not only describe the study techniques well enough for adequate replication but also to describe the specific context of the study. The participants in the present study engaged in RT during the Fall and Winter months prior to a vaccination being available. Therefore, it may have been an ideal time to engage in exercise in their own home. Future research may replicate components of this study and examine if different constructs (i.e. self-regulation) may be more important mediators.

The present study has several methodological strengths. We utilized the Template for Intervention Description and Replication (TIDieR) to ensure completeness in reporting intervention components (Appendix G). It is crucial to provide information that is specified in the TIDieR checklist. If an intervention did not impact mediators, it is important to have all the information as to why it was not successful. Perhaps a BCT is effective but the dose was not sufficient, or the provider was not trained and thus not qualified to provide the technique. Rather than deem the BCT ineffective, the conditions under which it was provided must be more closely examined. We describe and provide open access for the study materials (RTinHome.com), systematically described the procedures including: who provided the intervention and how the intervention was delivered (via Zoom and SMS messaging), the dose of the intervention, and the tailoring of the conversation with participants to barriers which are specific to them. Randomization occurred after two training sessions, therefore trainers were blinded to the future condition of the participants. Participants completed surveys before randomization, therefore

anticipation of group assignment would not influence intentions nor expectations to continue. Furthermore, we provided an a priori specification of the theory-based mechanisms of action through which the behavior change techniques were proposed to work. Hagger et al. (2020) write that it is important to have a clear description of the connection between the BCT proposed to affect change in the behavioral outcome of an intervention, and the constructs through which the intervention content is proposed to exert its effects. Behavior change research for RT is currently sparse. Future research in this field would be strengthened by providing this valuable information.

Future research should continue to utilize mediation analysis, specify the targeted constructs the intervention is aimed to intervene upon and test the individual effects of techniques by providing comparison groups with some form of active intervention rather than a control group that does not receive an intervention. Future research should also recruit larger sample sizes and follow participants over a longer time period.

Limitations and Future Directions

This study had a number of strengths including the following of the TIDieR checklist, the a priori specification of behavior change techniques, and mediation analysis. However, there are a few limitations that should be noted. First, the duration of the study was not long enough to gain an understanding of regular participation in strength training. For example, regular physical activity participation has been defined as at least 6 months (Huberty et al., 2008). Therefore, it is unknown what would have occurred if the intervention were extended, and measurements were taken over a longer time. The relative age homogeneity and modest sample size make attempts to generalize the results to different populations limited. Additionally, it cannot be ruled out that the intervention effects, particularly at post intervention were not due to a higher level of contact with the study team rather than the content that was delivered. Future research should match

contact time to identify the active ingredients of the intervention. Another limitation is the

reliance on self-reported data that was a function of the remote nature of this study. This self-

report data is subject to bias and memory recall issues. Even if the study had not been remote, it

is still a measurement challenge within the field to obtain objective measures of participation in

RT. To the authors knowledge, there is no published research which utilizes wearable technology

to objectively measure RT. This study was unable to track the analytics of the website use, some

websites may include login information where a researcher can track the number of occurrences

with which a participant logs onto a recorded routine.

Future research may consider more frequent daily, or weekly self-monitoring of behavior.

We asked participants to recall their RT behavior in the last week and four weeks. It is likely

challenging for participants to remember how much RT they did in the previous four weeks.

Furthermore, objective measures of strength improvement or health metrics may be beneficial

and should be included in future research. One last critique was the lack of program direction

and minimally available videos. Future in home RT research should give participants more

variety (more than 4 routines) and more specific directions on which routines to do each day.

Missing from our analysis was an assessment of socioeconomic factors and living

arrangements. Because the study was conducted during a shelter in place mandate and by nature

of the design, participants engaged in RT in their homes. It is possible that differences in living

environment (i.e. apartment vs house, living alone or living with others, available space) would

have an impact on behavior. We cannot rule out living arrangements and socioeconomic factors

as covariates because they were not assessed. Therefore, number of living partner, bedrooms,

square footage of living, and socioeconomic factors should be assessed.

Next, while a mediation analysis was conducted it is not possible to isolate the distinct effects of the utilized behavior change techniques. While the present intervention did have positive impacts on the targeted constructs it is challenging to tell specifically which technique (action planning, coping planning, SMS reminder) was the most beneficial. Future research should include a control group which receives some dose of a behavior change intervention to determine which components are additive and which are superfluous. When interventions have multiple behavior change techniques it is not possible to isolate the mechanisms of action (Hagger et al., 2020). Therefore, it is not possible to tell which specific techniques may be responsible for behavior change and whether they interact or act independently (Hagger et al., 2020).

Results from the present study may be used to inform future research. In home strength training may be an ideal initial first step for people to engage in RT. The RT website and training videos were fairly basic and were developed for this study by the researcher, they contained no additional information nor more sophisticated interactive components you might find on a commercial website. An upgraded website with more routines and specific directions could be developed to serve as the structure for many different behavioral research questions. Once participants have access to routines, equipment, and knowledge of how to complete RT safely, researchers could test adherence promotion strategy. Future research may want to consider different sources of influence. For example, in this study, only intrapersonal determinants of behavior were addressed. Other factors such as the environment and social influences should be factored in as these variables may explain differences in behavior. Future studies should also examine decreasing doses of coaching contact over time in an extended duration trial. In this study, participants went from meeting with the PI one time per week to zero times per week.

Perhaps, titrating contact to every other week and then monthly may prove to be useful for adhering to the program. Objective measures of strength and fitness should also be assessed and avenues to objectively measure the amount of RT need to be considered and explored. For example, a login page that tracks how often a participant utilizes a website that host RT videos.

In summary, this study found that a self-regulation based coaching intervention had positive impacts on the targeted psychological constructs. Changes in intention contributed to changes in behavior. Therefore, the intervention effects on behavior change were mediated through changes in intention. It is important to identify what works for whom under what circumstances. This study demonstrates that for 18-35 year old adults, in home strength training programs may benefit from the addition of brief coaching calls that focus on action planning, coping planning, and provide SMS reminder prompts. This is only the third RT study which performed a mediation analysis and is the first in which healthy young adults were participants. This study adds to the literature in that it was the first RCT aimed at promoting resistance training in healthy adult novices. The entire remote nature of the study allows for scalability and equitability as remote interventions can reach more individuals and cut cost. This study was also the third to utilize a mediation analysis, thus helping researchers understand which behavior change techniques may effect psychological correlates and which psychological correlates are related to RT behavior in the context of in home strength training. Previous research has suggested that changes in self-regulation contributed to changes in behavior. However, the present study does not support this. Future research should improve upon the present design by creating a digital platform with more resistance training routines and directions which also tracks online logins as a proxy for attendance. Subsequent studies should utilize longer time periods, including longer intervention periods and longer follow-up periods. It is recommended that

future research examine other constructs (i.e. identity, habit, autonomous motivation) which may also contribute to behavior change. Future comparison groups should receive some type of active intervention so that individual effects of behavior change techniques may be teased out.

In summary, this study found that a digital HAPA based intervention which utilized the behavior change techniques guided practice, action planning, coping planning, and SMS prompting had a positive effect on self-efficacy, intention, coping planning, and behavioral expectation. Changes in intention specifically contributed to changes in behavior. The intervention also had a significant yet temporary effect on behavior. While RT promotion research is sparse, the present study has strong methodological and analytical quality and adds to the research by examining mechanisms of behavior change. This is the first study to observe that changes in intention contributed to changes in behavior. It is important to examine what works for whom under what circumstances. This was the first in home and entirely remote RT promotion study. Thus, while previous research has highlighted the importance of self-regulation, this was the first study in this specific context with healthy adult novices. Future research should still consider self-regulation to be a potentially important construct. Subsequent studies should include more frequent measurement and examine ways to obtain more accurate data. Faded contact and longer study length should also be considered as should more than one comparison group. To examine scalability and equitability, researchers should consider what intervention components can be automated with the use of technology.

APPENDICES

Question	Eligible	Ineligible
1. How old are you right now?	18-35 Continue	<18 or >35 We are sorry, based on your age you are outside of the eligibility for this study. If you have any questions you can contact the lead investigator at justin.kompf001@umb.edu
2. Resistance training includes all exercises intended for enhancing muscle strength and endurance including weight bearing exercises (e.g. crunches, push-ups, squatting), exercises using simple dumbbells, tubes, and exercises using machines and barbells. In the past month, how many times have you engaged in resistance training.	<4 times	≥4 times We are sorry, based on your resistance training history you are outside of the eligibility for this study. If you are interested you can contact the lead investigator at justin.kompf001@umb.edu
3. PAR-Q+	No contraindications	We are sorry, based on your health history you are ineligible to participate in this study. If you have any questions you can contact the lead investigator at justin.kompf001@umb.edu
4. Contact information	Participants then provides email and cell phone number	

2019 PAR-Q+

The Physical Activity Readiness Questionnaire for Everyone

The health benefits of regular physical activity are clear; more people should engage in physical activity every day of the week. Participating in physical activity is very safe for MOST people. This questionnaire will tell you whether it is necessary for you to seek further advice from your doctor OR a qualified exercise professional before becoming more physically active.

GENERAL HEALTH QUESTIONS

Please read the 7 questions below carefully and answer each one honestly: check YES or NO.	YES	NO
1) Has your doctor ever said that you have a heart condition ☐ OR high blood pressure ☐?	☐	☐
2) Do you feel pain in your chest at rest, during your daily activities of living, **OR** when you do physical activity?	☐	☐
3) Do you lose balance because of dizziness **OR** have you lost consciousness in the last 12 months? Please answer **NO** if your dizziness was associated with over-breathing (including during vigorous exercise).	☐	☐
4) Have you ever been diagnosed with another chronic medical condition (other than heart disease or high blood pressure)? **PLEASE LIST CONDITION(S) HERE:** _____	☐	☐
5) Are you currently taking prescribed medications for a chronic medical condition? **PLEASE LIST CONDITION(S) AND MEDICATIONS HERE:** _____	☐	☐
6) Do you currently have (or have had within the past 12 months) a bone, joint, or soft tissue (muscle, ligament, or tendon) problem that could be made worse by becoming more physically active? Please answer **NO** if you had a problem in the past, but it **does not limit your current ability** to be physically active. **PLEASE LIST CONDITION(S) HERE:** _____	☐	☐
7) Has your doctor ever said that you should only do medically supervised physical activity?	☐	☐

If you answered NO to all of the questions above, you are cleared for physical activity.
Please sign the PARTICIPANT DECLARATION. You do not need to complete Pages 2 and 3.

- ▶ Start becoming much more physically active – start slowly and build up gradually.
- ▶ Follow International Physical Activity Guidelines for your age (www.who.int/dietphysicalactivity/en/).
- ▶ You may take part in a health and fitness appraisal.
- ▶ If you are over the age of 45 yr and NOT accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.
- ▶ If you have any further questions, contact a qualified exercise professional.

PARTICIPANT DECLARATION
If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that the community/fitness center may retain a copy of this form for its records. In these instances, it will maintain the confidentiality of the same, complying with applicable law.

NAME _____ DATE _____

SIGNATURE _____ WITNESS _____

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER _____

● If you answered YES to one or more of the questions above, COMPLETE PAGES 2 AND 3.

⚠ Delay becoming more active if:

- ✓ You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
- ✓ You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ at **www.eparmedx.com** before becoming more physically active.
- ✓ Your health changes - answer the questions on Pages 2 and 3 of this document and/or talk to your doctor or a qualified exercise professional before continuing with any physical activity program.

C: INFORMED CONSENT
Document of Informed Consent
Exercise and Health Sciences Department
University of Massachusetts at Boston

University of Massachusetts Boston
Department of Exercise and health Sciences
100 Morrissey Boulevard
Boston, MA 02125-3393

Consent Form for *A digital health action process approach intervention to promote resistance training behavior in healthy adult novices*

Introduction and Contact Information
You are asked to take part in a research study. **Participation is voluntary.** The researcher is Justin Kompf, PhD candidate, from the Exercise and Health Sciences Department. The faculty advisor is Jessica Whiteley, PhD, also from the Exercise and Health Sciences Department. Please read this form and feel free to ask questions. If you have questions, Justin Kompf will discuss them with you. His telephone number is 857-256-1334.

Description of the Project:
The purpose of this research is to examine if a coaching intervention based on theory can improve adherence to **in home** resistance training.

Your participation in this study will take approximately 9 weeks. If you decide to participate in this study, you will be asked to meet with a certified personal trainer from our research study team **over Zoom** for two resistance training workouts which will last for approximately 45 minutes. In these two sessions you will be taught 21 resistance training exercises which will train all your major muscle groups and will receive corrective feedback from certified personal trainers on the research study team.

After these two training sessions you have a 50% chance of being randomly assigned by a computer into either 1) **GROUP 1**: a group that gets access to all of routines you just learned in the training sessions on the study resistance training website or 2) GROUP 2: a group that also gets access to all of routines you just learned in the training sessions on the study resistance training website plus 4 additional coaching sessions. The website that both groups will have access to will contain four guided training videos, PDF's describing the routines, as well as the guidelines for resistance training. If you are randomized to GROUP 2, you will be asked to meet with the principal investigator (Justin Kompf) on four occasions spaced out by one week **also over Zoom**. These Zoom sessions will last for 20-25 minutes. These sessions will focus on time management, identifying barriers and developing solutions to engagement in resistance training.

All participants in both groups, will be given two dumbbells and one resistance tube for this study. These materials will be yours to keep at the end of your participation in the study. You will also receive a $10.00 Amazon gift card for each of the two times you complete the

questionnaires which will ask you about your behaviors, thoughts, and attitudes related to resistance training. Thus, you will receive the dumbbells, resistance bands, and up to $20 for completion of the study. Dumbbells and bands will be delivered in a safe manner that follows no contact guidelines set by the CDC. Gift cards are based on completing participation surveys. For each completed survey you will earn $10.00. These incentives are not based on your progress in the resistance training program.

Risks or Discomforts:
There are risks of physical discomfort when participating in resistance training. These risks primarily include muscular soreness. Your muscles may be tender to touch, feel tight, and slightly achy. Muscle soreness may occur 24-48 hours after your training. This risk will be minimized by teaching you a proper warm up as well as how to select an appropriate training load. Potential injury may occur; however, this risk is minimized through the two training sessions with corrective feedback prior to being randomly assigned your group and the use of lighter weights. You may also experience lightheadedness if exertion levels are higher than you are accustomed to. If you are concerned that you have injured yourself stop the exercise immediately and alert Justin Kompf as soon as you can by emailing or calling at 857-256-1334.

Another risk of participation is a loss of confidentiality. We will do everything we can to protect your information. Your identifying information will be kept in a password protected database. Your survey information will be stored separately, and your name will be replaced with an identification number.

Research-related Injury:
If you receive an injury at any point in the time that you are enrolled in the study that makes participation in resistance training painful or challenging, please cease from any form of exercise until you are cleared by a physician and notify the study team as soon as possible.

This study will not cover any cost related to medical care if you are injured during the program. You or your insurance carrier will be expected to pay the costs of this treatment. No additional financial compensation for injury or lost wages is available. You do not give up any of your legal rights by signing this form.

You may speak with Justin Kompf to discuss any distress or other issues related to study participation.

Benefits:
By participating in this study, you will learn how to engage in resistance training. Your participation may help us learn more about how to improve participation in resistance training. *Also, you may or may not receive the behavioral coaching sessions during the study depending on what group you are randomly assigned to.*

Alternatives:
You can get resistance training from other certified personal trainers without being in this study.

Confidentiality:
Your part in this research is **confidential**. That is, the information gathered for this project will not be published or presented in a way that would allow anyone to identify you. Information gathered for this project will be password protected or stored in a locked file cabinet and only the research team will have access to the data. The survey data that we collect will be associated with an ID number that is associated with your name. Thus, your responses will never be directly associated with your name.

The University of Massachusetts Boston Institutional Review Board (IRB) that oversees human research and its representatives may inspect and copy your information.

After all of your identifiers are removed from the information collected from this study, the de-identified information could be stored up through the final publication of the proposed research and used for future research studies or shared with another researcher for future research studies. In this case, you will not be asked again for your consent.

Voluntary Participation:
The decision whether to take part in this research study is voluntary. If you do decide to take part in this study, you may end your participation at any time without consequence. If you wish to end your participation, you should email the principal investigator (rtinhome@umb.edu) If you wish to not take the online survey you may close the survey and fully exit the web browser at any time and the data will not be retained. Whatever you decide will in no way penalize you or involve a loss of benefits to which you are otherwise entitled or affect your grades or relationship with UMass Boston.

Questions:
You have the right to ask questions about this research before you agree to be in this study and at any time during the study. If you have further questions about this research or if you have a research-related problem, you can reach Justin Kompf at rtinhome@umb.edu or by phone at 857-256-1334, or the faculty advisor for this research, Jessica Whiteley, at Jessica.whiteley@umb.edu.

If you have any questions or concerns about your rights as a research participant, please contact a representative of the Institutional Review Board (IRB), at the University of Massachusetts, Boston, which oversees research involving human participants. The Institutional Review Board may be reached by telephone or e-mail at (617) 287-5374 or at human.subjects@umb.edu.

Signatures:

You will be asked to consent to this study over the phone. Please keep a copy of this form for your records or if you need to contact me.

D: QUESTIONNAIRES

Self-Efficacy (General)

Rate how confident you are in your ability to successfully accomplish each of the following items. In the space provided to the right of each plan, indicate your degree of confidence, from 0 (no confidence at all) to 100 (completely confident).

1. I have confidence in my ability to learn weight training well

0	10	20	30	40	50	60	70	80	90	100
No confidence at all										Completely confident

2. I have confidence to perform weight training workouts on my own

0	10	20	30	40	50	60	70	80	90	100
No confidence at all										Completely confident

3. I can do two 30-minute weight training sessions per week

0	10	20	30	40	50	60	70	80	90	100
No confidence at all										Completely confident

4. I can do two 30-minute weight training sessions for the next 4 weeks

0	10	20	30	40	50	60	70	80	90	100
No confidence at all										Completely confident

5. I have confidence in my weight training performance

0	10	20	30	40	50	60	70	80	90	100
No confidence at all										Completely confident

6. I have confidence in my ability to handle weight room equipment

0	10	20	30	40	50	60	70	80	90	100
No confidence at all										Completely confident

7. I have confidence in my ability to design a proper weight training program myself

0	10	20	30	40	50	60	70	80	90	100
No confidence at all										Completely confident

8. I have confidence I have all the knowledge needed to perform weight training workouts well

0	10	20	30	40	50	60	70	80	90	100
No confidence at all										Completely confident

Affective Attitude

For me, engaging in resistance training two times per week over the next three weeks will be:

1	2	3	4	5	6	7	8	9
Extremely unenjoyable								Extremely enjoyable

1	2	3	4	5	6	7	8	9
Extremely boring								Extremely fun

1	2	3	4	5	6	7	8	9
Extremely unpleasant								Extremely pleasant

Behavioral Intention

1. How motivated are you to meet the strength training guidelines of two times per week for the next four weeks?

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
Extremely   Extremely
unmotivated   Motivated

2. How committed are you to engaging in strength training over the next four weeks?

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
Extremely   Extremely
uncommitted   committed

3. How motivated are you to increase the amount of strength training you are currently doing over the next four weeks?

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
Extremely   Extremely
unmotivated   unmotivated

4. To what extent do you find this statement true: "I strongly intend to do everything I can to strength train two times per week over the next four weeks.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
Extremely   Extremely
untrue   true

*the timeframe used will depend on the study length.

Behavioral Expectation

Please rate how likely you are, on a scale of 0–100%, to resistance train in each of the situations listed below. Please respond about your actual likelihood of resistance training, not your ideal or desired likelihood of resistance training.

1. When you have many household chores to do

0	10	20	30	40	50	60	70	80	90	100
Extremely unlikely										Extremely likely

2. When the gym is crowded

0	10	20	30	40	50	60	70	80	90	100
Extremely unlikely										Extremely likely

3. When you are busy and short of time

0	10	20	30	40	50	60	70	80	90	100
Extremely unlikely										Extremely likely

4. When you have many work/volunteer obligations

0	10	20	30	40	50	60	70	80	90	100
Extremely unlikely										Extremely likely

5. When you are traveling

0	10	20	30	40	50	60	70	80	90	100
Extremely unlikely										Extremely likely

6. When it is difficulty to fit time into your schedule

0	10	20	30	40	50	60	70	80	90	100
Extremely unlikely										Extremely likely

7. When you have many family obligations

0	10	20	30	40	50	60	70	80	90	100
Extremely unlikely										Extremely likely

8. When there are more fun or more interesting things to do

0	10	20	30	40	50	60	70	80	90	100
Extremely unlikely										Extremely likely

9. When you are tired

0	10	20	30	40	50	60	70	80	90	100
Extremely unlikely										Extremely likely

10. When you feel discouraged about your resistance training

0	10	20	30	40	50	60	70	80	90	100
Extremely unlikely										Extremely likely

11. When there is no positive reinforcement for your resistance training

0	10	20	30	40	50	60	70	80	90	100
Extremely unlikely										Extremely likely

12. When there is no one to resistance train with you

0	10	20	30	40	50	60	70	80	90	100
Extremely unlikely										Extremely likely

Behavior Questionnaire

1. During the last seven days (a week), how many times on did you do resistance training?

2. In the last 4 weeks (28 days), approximately how many times have you done resistance training?

E: EMAIL SCRIPTS

Thank you for your interest in participating in our resistance training study. In this study you will learn how to do several resistance training exercises under the supervision of a certified personal trainer. Here are several things you should know and expect for your first visit:

Attire: Be sure to bring comfortable clothing (i.e. shorts, t shirt, athletic footwear, sweatpants) for your first session. You will be actively engaging in these exercises.

Length: Plan on blocking out at least 45 minutes for your first session. The resistance training session should last no longer than 30 minutes. Once the session is complete you will be asked to complete a questionnaire.

Please click the link below to pick a time that works best for you to come in for your first training session. We will follow up with you with an email and a text message to confirm your session. If you have any questions, please feel free to contact us at justin.kompf001@umb.edu

F: TIDieR CHECKLIST FOR PROPOSED STUDY (Hoffman et al., 2014).

Item number	Item
Brief name	
1	
Provide the name or a phrase that describes the intervention	A digital Health Action Process Approach intervention to promote resistance training behavior in healthy adult novices
Why	
2	
Describe any rationale, theory, or goal of the elements essential to the intervention	This study is based on the Health Action Process Approach
What	
3	
Materials: Describe any physical or informational materials used in the intervention, including those provided to participants or used in intervention delivery or in training of intervention providers. Provide information on where the materials can be accessed (such as online appendix, URL	All participants will receive the following (2) dumbbells and a single band (2) access to Vimeo prerecorded training videos which are hosted on rtinhome.com and (3) a digital education packet.
4	
Procedures: Describe each of the procedures, activities, and/or processes used in the intervention, including any enabling or support activities	Three phase intervention with two Zoom based training sessions in Phase I, the use of action planning, coping planning, and SMS prompting in Phase II for the intervention group.
Who Provided	
5	
For each category of intervention provider (such as psychologist, nursing assistant), describe their expertise, background, and any specific training given	Certified personal trainers (NSCA, ACSM, or NASM) will provide the instructions in phase 1. The PI will provide the Digital RT + Behavioral Coaching in phase 2 and phase 3. The certified personal trainers will undergo training.
How	
6	
Describe the modes of delivery (such as face to face or by some other mechanism, such as internet or telephone) of the intervention and whether it was provided individually or in a group	RT coaching sessions are conducted over Zoom. Digital RT + Behavioral conducted over Zoom. Training videos are hosted on the website RTinHome.com. Graphic material and educational manuals will be hosted on RTinHome.com
Where	
7	
Describe the type(s) of location(s) where the intervention occurred, including any necessary infrastructure or relevant features	All training will occur in participants' homes.
When and How Much	
8	
Describe the number of times the intervention was delivered and over what period of time including the number of sessions, their schedule, and their duration, intensity, or dose	A total of two guided RT sessions, a total of four coaching sessions, separated by 1 week lasting 20 minutes. Sessions focusing on enhancing coping planning and behavioral expectations.
Tailoring	
9	
If the intervention was planned to be personalised, titrated or adapted, then describe what, why, when, and how	The behavioral intervention starts with a script but the aspects of the script will be tailored to participants needs.

REFERENCES

Abraham. C., Michie, S. (2008). A taxonomy of behavior change techniques used in

    interventions. *Health Psychology*. 27(3), 379-387.

American College of Sports Medicine. (2009). American college of sports medicine position

    stand. Progression models in resistance training for healthy adults. *Medicine and Science*

    in Sport and Exercise. 41(3), 687-708.

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision*

    Processes. 50,179-211.

Ayotte, B.J., Margrett, J.A., Patrick, J.H. (2010). Physical activity in middle-aged and young-old

    adults. *Journal of Health Psychology*. 15(2), 173-185.

Bandura, A. (1991). Social cognitive theory of self-regulation. *Organizational Behavior and*

    Human Decision Processes, 50, 248-287.

Bandura, A. (2004). Health promotion by social cognitive means. *Health Education & Behavior.*

    31(2), 143-164.

Behmn, D.G., Faigenbaum, A.D., Falk, B., Klentrou, P. (2008). Canadian Society for Exercise

    Pysiology position paper: Resistance training in children and adolescents. *Applied*

    Physiology, Nutrition, and Metabolism. 33(3), 547-561.

Belanger-Gravel, A., Godin, G., Amireault, S. (2013). A meta-analytic review of the effect of

    implementation intentions on physical activity. *Health Psychology Review*. 1, 1-32.

Blair, S.N. (2009). Physical inactivity: The biggest public health problem of the 21st century.

    British Journal of Sports Medicine. 43(1), 1-2.

Blanchard, C.M., Fortier, M., Sweet, S., O'Sullivan, T.O., Hogg, W., Reid, R.D., Sigal, R.C. (2007). Explaining physical activity levels from a self-efficacy perspective: The physical activity counseling trial. *Annals of Behavioral Medicine,* 34, 323–328.

Bourdeaudhuji, D., Sallis, J. (2002). Relative contribution of psychosocial variables to the explanation of physical activity in three population-based adult samples. *Preventive Medicine.* 34(2), 279-288.

Bryan, A.D., Rocheleau, C.A. (2002). Predicting aerobic versus resistance exercise using the theory of planned behavior. *American Journal of Health Behavior.* 26(2), 83-94.

Cardinal, B.J., Keis, J.S., Ferrand, C. (2005). Comparison of American and French college students' stage of change for muscular fitness-promoting behaviors. *American Journal of Health Promotion.* 20:388–91.

Cardinal, B.J., Kosma, M. (2004). Self-efficacy and the stages and processes of change associated with adopting and maintaining muscular fitness-promoting behaviors. *Research Quarterly for Exercise and Sport.* 75(2), 186-196.

Caspersen, C.J., Powell, E.C., Christenson, G.M. (1985). Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health.* 100, 126-131.

Center for Disease Control and Prevention. National center for chronic disease prevention and health Promotion, Division of Nutrition, Physical Activity, and Obesity. Data, Trend and Maps [accessed Jan 12, 2020].

Choi, J., Lee, M., Lee, J., Kang, D., Choi, J. (2017). Correlates associated with participation in physical activity among adults: A systematic review of reviews and update. *BMC Public Health.*

Courneya et al. (2004). Three independent factors predicted adherence in a randomized

    controlled trial of resistance exercise training among prostate cancer survivors. *Journal of*

    Clinical Epidemiology. 57, 571-579.

Davies CA, Spence JC, Vandelanotte C, Caperchione CM, Mummery WK. Meta-analysis of

    internet-delivered interventions to increase physical activity levels. (2012). International

    Journal of Behavior Nutrition and Physical Activity. 9:52. doi: 10.1186/1479-5868-9-

Dawson, K.A., Brawley, L.R. (2000). Examining the relationship between exercise goals, self-

    efficacy, and overt behavior with beginning exercisers. *Journal of Applied Social*

    Psychology. 30(2), 315-329.

Dean, R.N., Farrell, J.M., Kelley, M.L., Taylor, M.J., Rhodes, R.E. (2006). *Journal of Aging and*

    Physical Activity. 15, 1-12

Deci, R.M., Ryan, E.L. (2017). Self-determination theory: Basic psychological needs in

    motivation, development, and wellness. Guilford Press

Enders, C.K., Bandalos, D.L. (2001). The relative performance of full information maximum

    likelihood estimation for missing data in structural equation models. Structural Equation

    Modeling. 8:3, 430-457.

Eng TR. The ehealth landscape: a terrain map of emerging information and communication

    technologies in health and health care. Princeton, NJ: Robert Wood Johnson Foundation;

    2001

Eynon, M., Foad, J., Downey, J., Bowmer, Y., Mills, H. (2018). Assessing the psychosocial

    factors associated with adherence to exercise referral schemes: A systematic review.

    Scandinavian Journal of Medicine and Science in Sports. 29: 638-650.

Fetherman, D.L., Hakim, R.M., Sanko, J.P. (2011). A pilot study of the application of the transtheoretical model during strength training in older women. *Journal of Women and Aging.* 23, 58-76.

Fischer X., Kreppke, J.N., Zahner, L., Gerber, M., Faude, O., Donath, L. (2019). Telephone-based coaching and promoting for physical activity: Short-and long-term findings of a randomized controlled trial (Movingcall). *International Journal of Environmental Research and Public Health*. 16, 2626.

Fjeldsoe, B.S., Marshall, A.L., Miller, Y.D. (2009). Behavior change interventions delivered by mobile telephone short-message service. *American Journal of Preventative Medicine*. 36, 165-173.

Forbes, C.C., Blanchard, C.M., Mummery, K., Courneya, K.S. (2015). Prevalence and correlates of strength exercise among breast, prostate, and colorectal cancer survivors. *Oncology Nursing Forum.* 42(2), 1-10.

Gao, Z., Hannon, J.C., Yi, X. (2007). Examining the role of self-efficacy and three types of outcome expectations in weight training. *Perceptual and Motor Skills.* 105, 707-713.

Gao, Z., Kosma, M. (2008). Intention as a mediator of weight training behavior among college students: An integrative framework. *Journal of Applied Sport Psychology.* 20: 1-12.

Gao, Z., Xiang, P., Lee, A.M. (2008). Self-efficacy and outcome expectancy in beginning weight training class: Their relations to students' behavioral intention and actual behavior. *Research Quarterly for Exercise and Sport.* 79(1), 92-100.

Godin, G., Conner, M.T., (2008). Intention-behavior relationship based on epidemiologic indices: An application to physical activity. *American Journal of Health Promotion*. 22(3), 180-182.

Godin, G., Shephard, R.J. (1985). A simple method to assess exercise behaviour in the

    community. Canadian Journal of Applied Sport Science, 10, 141–146.

Goode, A.D., Reeves, M.M., Eakin, E. (2012). Telephone-delivered interventions for physical

    activity and dietary behavior change: An updated systematic review. *American Journal of*

    Preventative Medicine. 42(1), 81-88.

Gordon, B.R., McDowell, C.P., Hallgren, M., Meyer, J.D., Lyons, M., Herring, M.P. (2018).

    Association of efficacy of resistance exercise training with depressive symptoms. Meta-

    analysis and meta-regression analysis of randomized clinical trials. *JAMA Psychiatry*.

    75(6):566-576.

Hagger, M., Moyers, M.S., McAnally, K., McKinley, L.E. (2020). Known knowns and known

    unknowns on behavior change interventions and mechanisms of action. *Health*

    Psychology Review. 14(1), 199-212.

Harada, K., Oka, K., Shibata, A., Ota, A., Okada, J., Nakamura, Y. (2008). Factors associated

    with stages of change for strength training behavior. *International Journal of Sport and*

    Health Science. 6, 251-263.

Hass, C.J., Feigenbaum, M.S., Franklin, B.A. (2001). Prescription of resistance training for

    healthy population. *Sports Medicine*. 31(14), 953-964.

Howlett, N., Schulz, J., Trivedi, D., Troop, N., Chater, A. A prospective study exploring the

    construct and predictive validity of the COM-B model for physical activity. *Journal of*

    Health Psychology. 24(10), 1378-1391.

Huberty. J.L., Ransdell, L.B., Sidman, C., Flohr, J.A., Shultz, B., Grosshans, O., Durrant, L.

    (2008). Explaining long term exercise adherence in women who complete a structured

    exercise program. *Research Quarterly for Exercise and Sport*. 79(3), 1-11.

Jette, A.M., et al. (1998). Home-based resistance training: Predictors of participation and

      adherence. *The Gerontologist.* 38 (4), 412-421.

Karoly, P., Ruehlman, L.S., Okun, M.A., Lutz, R.S., Newton, C., Fairholme, C. (2005).

      Perceived self-regulation of exercise goals and interfering goals among regular and

      irregular exercisers: A life space analysis. *Psychology of Sport and Exercise*. 6: 427-422.

Kathrins, B.P., Turbow, D.J. (2010). Motivation of fitness center participants toward resistance

      training. *Strength and Conditioning Journal.* 24(9), 2483-2490.

Kaushal, N., Keither, N., Aguinaga, S., Hagger, M.S. (2020). Social cognitive and

      socioecological predictors of home-based physical activity intention, planning, and habits

      during the COVID-19 Pandemic. Behavioral Sciences.10, 133.

Kok, G. (2014). A practical guide to effective behavior change: How to apply theory-and

      evidence-based behavior change methods in an intervention. *European Health*

      Psychologist. 16(5), 156-170.

Kok et al. (2016). A taxonomy of behaviour change methods: an intervention mapping approach.

      Health Psychology Review. 10(3), 297-312.

Koring, M., Richert, J., Lippke, S., Parschau, L., Reuter, T., Schwarzer, R. (2012). Synergistic

      effects of planning and self-efficacy on physical activity. *Health Education & Behavior.*

      39(2) 152-158.

Kruger, J., Carlson, S., & Kohl, H. (2006). Trends in strength training- United States, 1998-2004.

      Morbid Mortal Weekly Report. 55, 769-772.

Lally, P., Gardner, B. (2013). Promoting habit formation. *Health Psychology Review*. 7(1), 137-

      158.

Lippke, S., Wiedemann, A.U., Ziegelmann, J.P., Reuter, T. (2009). Self-efficacy moderates intention into behavior via plans. *American Journal of Health Behavior*. 33(5), 521-529.

Lubans, D.R., Plotnikoff, R.C., Jung, M., Eves, N., Sigal, R. (2012). Testing mediator variables in a resistance training intervention for obese adults with type 2 diabetes. *Psychology & Health.* 27(12), 1388-1404

Maddux, J.E., Rogers, R.W. (1982). Protection motivation and self-efficacy: A revised theory of fear appeals and attitude change. *Journal of Experimental Social Psychology.* 19(5), 469-479.

Marsh, H.W., Hau, K.T., Wen, Z. (2004). In search of golden rules: Comment on hypothesis-testing approaches to setting cutoff values for fit indexes and dangers in overgeneralizing Hu and Bentler's (1999) findings. Structural Equation Modelling A Multidisciplinary Journal. 11: 320–341

McAuley, E. (1992). The role of efficacy cognitions in the prediction of exercise behavior in middle-aged adults. *Journal of Behavioral Medicine.* 15(1), 65-88.

Michie, S., Abraham, C. (2004). Interventions to change health behaviours: evidence-based or evidence inspired? *Psychology & Health*. 19(1): 29-49.

Michie, S., Ashford, A., Sniehotta, F.F., Dombrowski, S.U., Bishop, A., French, D.P. (2011). A refined taxonomy of behaviour change techniques to help people change their physical activity and healthy eating behaviors: The CALO-RE taxonomy. *Psychology & Health.* 26(11), 1479-1498.

Michie, S., van Stralen, M.M., West, R. (2011). The behavior change wheel: A new method for characterizing and designing behaviour change interventions. *Implementation Science.* 6(1):42.

Michie, S., et al. (2013). The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: Building an international consensus for the reporting of behavior change interventions. *Annals of Behavioral Medicine*. 56: 81-95.

Millen, J.A., Bray, S.R. (2009). Promoting self-efficacy and outcome expectations to enable adherence to resistance training after cardiac rehabilitation. *Journal of Cardiovascular Nursing*. 24(4), 316-327.

Murray, J.M., French, D.P., Kee, F., Gough, A., Tang, J. (2020). Mechanisms of physical activity behavior change in an incentive-based intervention: Mediation analysis. *Health Psychology. 3*9(4), 281-297.

Neupert, S.D., Lachman, M.E., Whitbourne, S.B. (2009). Exercise self-efficacy and control beliefs predict exercise behavior after an exercise intervention for older adults. *Journal of Physical Activity.* 17(1), 1-16.

Nigg, C.R., Borrelli, B., Maddock, J., & Dishman, R.K. (2008). A theory of physical activity maintenance. *Applied Psychology: An International Review*. 57, 544–560

Nugent, C. (2016). QuickStats: Percentage of U.S. adults who met the 2008 federal physical activity guidelines for aerobic and strengthening activity, by sex- National Health Interview Survey, 2000-2014. *Morbidity and Mortality Weekly Report*. 65,(485). DOI: httpL//dx/doi.org/10.15585/mmwr.mm6518a9

Ott, C.D., et al., (2004). Facilitative strategies, psychological factors, and strength/weight training behaviors in breast cancer survivors who are at risk for osteoporosis. *Orthopaedic Nursing*. 23(1), 45-52.

Paech, J., Lippke, S. (2017). Social-cognitive factors of long-term physical exercise 7 years after orthopedic treatment. *Rehabilitation Psychology*. 62(2), 89-99.

Patterson, M.S., Umstattd Meyer, R.M., Beville, J.M. (2015). Potential predictors of college women meeting strength training recommendations: Applications of the integrated behavioral model. *Journal of Physical Activity and Health.* 12, 998-1004.

Plotnikoff, R.C., Trinh, L., Courneya, K.S., Karunamuni, N., Sigal, R.J. (2009). Predictors of aerobic physical activity and resistance training among Canadian adults with type 2 diabetes: An application of the Protection Motivation Theory. *Psychology of Sport and Exercise*. 320-328.

Plotnikoff, R.C., Trinh, L., Courneya, K.S., Karunamuni, N., Sigal, R.J., Padwal, R., Karunamuni, N. (2010). Multicomponent, home based resistance training for obese adults with type 2 diabetes: A randomized controlled trial. *International Journal of Obesity.* 1(34), 1-9.

Plotnikoff, R.C., Courneya, K.S., Trinh, L., Karunamuni, N., Sigal, R.J. (2008). Aerobic physical activity and resistance training: an application of the theory of planned behavior among adults with type 2 diabetes in a random, national sample of Canadians. *International Journal of Behavioral Nutrition and Physical Activity*. 5:61

Prestwich, A., Perugini, M., Hurling, R. (2009). Can the effects of implementation intentions on exercise be enhanced using text messages? Psychology & Health. 24(6), 677-687.

Prochaska, J.O., Velicer, W.F. (1997). The transtheoretical model of health behavior change. *American Journal of Health Promotion*. 12(1), 38-48.

Rhodes, R.E., Boudreau, P., Josefsson, K.W., Ivarsson, A. (2020). Mediators of physical activity behaviour change interventions among adults: A systematic review and meta-analysis. *Health Psychology Review*.

Rhodes, R.E., Dickau, L. (2012). Experimental evidence for the intention-behavior relationships in the physical activity domain: A meta-analysis. *Health Psychology.* 31(6), 724-727.

Rhodes, R.E., Janssen, I., Bredin, S.D., Warburton, D.E., Bauman, A. (2017). Physical activity: Health impact, prevalence, correlates, and interventions. *Psychology & Health*. 32(8), 942-975.

Rhodes, R.R., Lubans, D.R., Karunamuni, N., Kennedy, S., Plotnikoff, R. (2017). Factors associated with participation in resistance training: A systematic review. *British Journal of Sports Medicine.* 51: 1466-1472.

Rhodes, R.E., Williams, D.M., Mistry, C.D. (2016). Using short vignettes to disentangle perceived capability from motivation: A test using walking and resistance training behaviors. *Psychology, Health, & Medicine*. 21(5), 639-651.

Rhodes, R.E., Blanchard, C.M., Matheson, D.H. (2007). Motivational antecedent beliefs of endurance, strength, and flexibility activities. *Psychology, Health, & Medicine.* 12(2), 148-162.

Rhodes R.E., Janssen, I., Bredin, S.D., Warburton, D.R, Bauman A. (2017). Physical activity: health impact, prevalence, correlates and interventions. *Psychology and Health.* 32(8), 942–75.

Rhodes, R.E., Yao, C.A. (2015). Models accounting for intention-behavior discordance in the physical activity domain: A user's guide, content overview, and review of current evidence. *International Journal of Behavioral Nutrition and Physical Activity*. 12 (9).

Rhodes, R.E., Lubans, D.R., Karunamuni, N., Kennedy, S., Plotnikoff, R. (2017). Factors associated with participation in resistance training: A systematic review. *British Journal of Sports Medicine.* 51(20), 1466-1472.

Rinaldi-Miles, A., Das, B.M., Kakar, R.S. (2019). Evaluating the effectiveness of

      implementation intentions in a pedometer worksite intervention. *Work*. 64, 777-785.

Rovniak, L.S., Anderson, E.S., Winett, R.A., Stephens, R.S. (2002). Social cognitive

      determinants of physical activity in young adults: A prospective structural equation

      analysis. *Annals of Behavioral Medicine.* 24(2), 149-156.

Rucker, D.D., Preacher, K.J., Tormala, Z.L., Petty, R.E. (2011). Mediation analysis in social

      psychology: Current practices and new recommendations. *Social and Personality*

      Psychology Compass. 5(6), 359-371,

Samdal, G.B., Eide, G.E., Barth, T., Williams, G., Meland, E. (2017). Effective behaviour

      change techniques for physical activity and healthy eating in overweight and obese

      adults; systematic review and meta-regress analyses. *International Journal of Behavioral*

      Nutrition and Physical Activity. 14:42

Schroe, H., Van Dyck, D., De Paepe, A, Poppe, L., Loh, W.W., Verloigne, M., Loeys, T., De

      Bourdeaudhuji, I., Crombez, G. (2020). Which behaviour change techniques are effective

      to promote physical activity and reduce sedentary behavior in adults: A factorial

      randomized trial of an e-and m-health intervention. *International Journal of Behavioral*

      Nutrition and Physical Activity. 17: 127.

Schwarzer, R. (2016). Health action process approach (HAPA) as a theoretical framework to

      understand behavior change. *Actualidades en Psicologica.* 30(121), 119-130

Schwerdtfeger, A.R., Schmitz, C., Warken, M. (2012). Using text messages to bridge the

      intention-behavior gap? A pilot study on the use of text message reminders to increase

      objectively assessed physical activity in daily life. *Frontiers in Psychology*. 3(270).

Sheeran, P. (2002). Intention-behavior relations: A conceptual and empirical review. *European Review of Social Psychology*. 12(1), 1-36.

Sheeran, P., Milne, S., Webb, T.L., Gollwitzer, P.M. (2005). Implementation intentions and health behaviour. Predicting health behaviour. New York. 276-323.

Sherwood, N.E., Jeffery, R.W. (2000). The behavioral determinants of exercise: Implications for Physical Activity Interventions. *Annual Review of Nutrition*. 20, 21-44.

Short, C.E., James, E.L., Vandelanotte, C., Courneya, K.S., Duncan, M.J., Rebar, A., Plotnikoff, R.C. (2014). Correlates of resistance training in post-treatment breast cancer survivors. *Support Cancer Care*. 22, 2757-2766.

Smith, D.M., Duque, L., Huffman, J.C., Healy, B.C., Celano, C.M. (2020). Text message interventions for physical activity: A systematic review and meta-analysis. *American Journal of Preventative Medicine.* 58(1): 142-151

Sniehotta, F.F. (2009). Toward a theory of intentional behaviour change: plans, planning, and self-regulation. *British Journal of Health Psychology.* 14, 261-273.

Sniehotta, F.F., Schwarzer, R., Scholz, U., Schuz, B. (2005). Action planning and coping planning for long-term lifestyle change: Theory and assessment. *European Journal of Social Psychology.* 35, 565-575.

Sullivan, A.N., Lachman, M.E. (2017). Behavior change with fitness technology in sedentary adults: A review of the evidence for increasing physical activity. *Frontiers in Public Health*. 4, 289.

Sweet, S.N., Fortier, M.S., Strachan, S.M., and Blanchard, C.M. (2012). Testing and integrating self-determination theory and self-efficacy theory in a physical activity context. (2012). *Canadian Psychology* 53(4), 319-327.

Vallerand, J.R., Rhodes, R.E., Walker, G.J., Courneya, K.S. (2016). Understanding strength

      exercise intentions and behavior in hematologic cancer survivors: An analysis of the

      intention-behavior gap. *Journal of Cancer Survivor*. 10, 945-955.

Van Roie, E., Bautmans, I., Coudyzer, W., Boen, F., Delecluse, C. (2015). Low-and high-

      resistance exercise: Long-term adherence and motivation among older adults.

      Gerontology. 61(6), 551-560.

Wang, J.B., Cadmus-Bertram, L.A., Natarajan, L., White, M.M., Madanat, H, Nichols, J.F.,

      Ayala, G.X., Pierce, J.P. (2015). Wearable sensor/device (Fitbit One) and SMS text-

      messaging prompts to increase physical activity in overweight and obese adults: A

      randomized controlled trial. *Telemedicine and e-Health*. 21(10): 782-792.

Warburton, D.E., Jamnik, V.K., Brendin, S.S., Glendhill, N. (2011). International launch of the

      PAR-Q+ and ePARmed-X+ the physical activity readiness questionnaire for everyone

      (PAR-Q+) and electronic physical activity readiness medical examination (ePARmed-

      X+). *Health and Fitness Journal of Canada*. 4(2), 3-23.

Webb, T.L., Sheeran, P. (2006). Does changing behavioral intentions engender behavior change?

      A meta-analysis of the experimental evidence. *Psychological Bulletin.* 132(2), 249-268.

Westcott, W.L. (2012). Resistance training is medicine: Effects of strength training on health.

      Current Sports Medicine Report. 11(4), 209-216.

Williams, D.M., Salva, J., Davy, B.M., Kelleher, S.A., Marinik, E.L., Winett, R.A. (2015).

      Questionnaires for outcome expectancy, self-regulation, and behavioral expectation for

      resistance training among young-old adults: Development and preliminary validity.

      Journal of Aging and Physical Activity. 23, 279-285.

Williams, D.M., Dunsiger, S., Davy, B.M., Kelleher, S.A., Marinik, E.L., Winett, R.A. (2016).
Psychosocial mediators of a theory-based resistance training maintenance intervention for
prediabetic adults. *Psychology & Health*. 31(9), 1108-1124.

Winett, R.A. et al. (2011). Theory-based approach for maintaining resistance training in older
adults with prediabetes: Adherence, barriers, self-regulation strategies, treatment fidelity,
cost. *Translational Behavioral Medicine*. 5(2):149-59

Wing, R.R., & O'Hill, J.O. (2001). Successful weight loss maintenance. *Annual Review of
Nutrition*. 21, 323-341.

World Health Organization. (2010). Global recommendations on physical activity for health.
Geneva, Switzerland: WHO.

World Health Organization. (2020). World Health Organization 2020 guidelines on physical
activity and sedentary behaviour. *British Journal of Sports Medicine*. 54: 1451-1462.

Zhang, C.Q., Zhang, R., Schwarzer, R., Hagger, M.S. (2019). A meta-analysis of the health
action process approach. *Health Psychology*. 38(7), 623-637.