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Description of Self-Regulation in Health Behavior Change Using Ecological Momentary Assessments

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DESCRIPTION OF SELF-REGULATION IN HEALTH BEHAVIOR CHANGE USING ECOLOGICAL MOMENTARY ASSESSMENTS

by

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ABSTRACT

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Despite the known associations between unhealthy behaviors and disease, reduced quality of life, and morbidity, individuals struggle to initiate and maintain health behavior change. Self-regulation is a process that includes activities in which people engage to achieve a goal. Poor self-regulation (i.e., inability to set specific, achievable goals; impaired planning skills; limited emotional control) may contribute to unhealthy behaviors across the lifespan. Self-regulation as a concept is inconsistently applied and inadequately understood. The purpose of this secondary analysis of Ecological Momentary Assessment (EMA) data was to develop an in-depth description of self-regulation, as conceptualized in Ryan's Integrated Theory of Health Behavior Change (2009), during the first three months of a behavior change intervention promoting osteoporosis prevention. Participants were 95 healthy women, ages 40 to 60, with no previous diagnosis of osteoporosis, who received a theory-based, individually-tailored intervention delivered via a smartphone app promoting health behavior change in four areas: calcium intake, physical activity, strength, and balance. The EMAs (each consisting of two questions) provided real-time, ecologically valid measurements of participants self-reported engagement in the osteoporosis preventions areas and, which self-regulation activities were performed. A total of 13,310 EMAs were completed during the 12 weeks. Calcium intake was reported most frequently during this period (n = 7368; 55.4% of all EMAs), followed by physical activity (n =

6038; 45.4% of all EMAs). Goal-setting (self-regulation activity), planning (self-regulation activity), and self-management behaviors (proximal outcome) were the most frequently reported activities across all four prevention areas. The self-regulation activity of tracking was reported at higher frequencies for calcium and physical activity than for balance or strength. For balance and strength, participants were more likely to report engaging in the self-regulation activity of self-evaluation. Findings suggest that participants do not equally pursue multiple prevention areas simultaneously nor do they equally utilize multiple, self-regulation activities. This study's description of an imperfectly understood concept, frequently incorporated in self-management and health behavior change interventions, suggests that theoretical assumptions of how people pursue change does not coincide with their real-world treatment of the behavior change process. Future research would include self-regulation activity use among different populations with different health risks and conditions. Policy and practice should consider piloting programs that include, at minimum, the self-regulation activities of goal-setting and planning as vital to any health behavior change skillset presented to patients or the public.

To

David and Nancy Brown, for giving me life,

Dr. Scott Kamelle and his team of nurse practitioners, for saving it,

My husband Sam Stern, for making every day a joy to live

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CHAPTER 1

Statement of The Problem

How people change and maintain health behaviors is poorly understood. Yet changing individual behaviors and sustaining those changes is becoming foundational to improving health. By the middle of the 20th century, large-scale studies such as the Framingham Heart Study and the Seven Countries Study identified a major contributing factor to chronic diseases – individual decisions regarding health behaviors (Foody, Mendys, Liu, & Simpson, 2010). These studies elucidated the contributions of cigarette smoking, diet, physical inactivity, and high blood pressure to the leading causes of death (Foody et al., 2010). At that time, reactive healthcare models that responded to acute health events after they occurred began to disappear (Dixon-Fyle, Gandhi, Pellathy, & Spatharou, 2012). Public health began emphasizing patients and families, health promotion, disease prevention, and continual management of chronic conditions (Dixon-Fyle et al., 2012). This ongoing change in direction has recently manifested in U.S. government policies. In his 2015 State of the Union address, President Obama announced a $215 million Precision Medicine initiative (also referred to as Precision Health) based on "patient-powered research" including genomic, molecular, biobehavioral, and environmental factors contributing to health and wellness. These variables are being identified, measured, and analyzed by researchers and clinicians to usher in new knowledge and tools that aid patients in making the best treatment and health-related decisions possible (The White House, 2015).

This transitioning outlook, which includes phenomenon like Precision Health, has clinicians and researchers focused on preventing disease instead of managing and curing conditions after they strike. Stemming illness before it starts is an ongoing process in a global environment where people are not only living longer, but they are living sicker as well. As of

2012, approximately half of all adults living in the United States – 117 million people – had one or more chronic health conditions (Ward, Schiller, & Goodman, 2014). One in four adults had two or more chronic health conditions (Ward et al., 2014). Heart disease, stroke, cancer, type 2 diabetes, obesity, and arthritis are among the most common, costly, and preventable of all health problems (Ward et al., 2014). These illnesses not only have a negative impact on quality of life, but they are costly in other ways. Bloom et al. (2011) estimated that non-communicable diseases result in economic losses for developing economies equivalent to 4 percent or 5 percent of their GDP per annum. Despite these consequences of poor health behaviors and the lack of sustained health behavior change, public interest in health matters is on the rise. The public is inundated with advertisements for drug remedies to health problems that could be managed with lifestyle choices instead of expensive pharmaceutical interventions. Unless healthcare professionals and systems find ways to foster individual behavior change and maintenance, healthcare costs will be untamable. Quality of and access to care will be jeopardized when supply cannot keep pace with demand.

As the results of public health studies like the Framingham Heart Study suggest, individuals are the critical participants in the development and successful maintenance of health behavior change. Whatever other factors may impact behaviors, from molecular to motivational, efforts to influence health habits are unlikely to produce lasting behavioral changes unless people develop skills to exercise control over their health-related activities, for example, setting health goals and taking self-directed steps to meet those goals. Though the consequences of poor health choices can be readily identified, there are opportunities to improve our understanding of how to aid individuals in achieving lasting health behavior change.

The primary purpose of this study was to provide an in-depth description of self-

regulation, as presented in Ryan's Integrated Theory of Health Behavior Change (Ryan, 2009). Self-regulation refers to the activities undertaken in the process of pursuing goals and, in the context of this study, these goals are related to health behavior change and maintenance. For the current study, the description of the self-regulation process was based on data collected from a specific group of women actively pursuing health goals. These women were participants in an osteoporosis prevention study that focused on health behavior change related to four specific areas: calcium intake from diet, strength, balance, and physical activity. The next section provides a summary of current knowledge and gaps in understanding regarding health behavior change, including the concept of self-regulation.

Health Behavior Change: Understanding and Limitations

The last 50 years of research in the realm of health behavior has resulted in a better understanding of the motivation and factors influencing change. Researchers examined health behaviors across a wide range of conditions, populations, and environments, testing various interventions and theories along the way. Formulations of the health behavior change process are derived from a variety of sources including the Institute of Medicine's report on Health and Behavior (Institute of Medicine [IOM], 2001) along with health behavior theories and research, including theories of health behavior change, self-regulation, social support, and chronic illness self-management.

This body of work has led to the discovery that individuals are more likely to initiate and maintain recommended health behaviors if they: (a) have information about and adopt, or already possess, health beliefs congruent with their behaviors; (b) develop and practice self-regulation activities to alter their health behaviors; and (c) experience social facilitation that supports engaging in these behaviors (Lorig, Ritter, & Plant, 2005). Behavioral scientists learned that

knowledge and beliefs influence behavior-specific self-efficacy, outcome expectancy, and goal congruence (Bandura, 1997). There is evidence that self-regulation activities includes goal adoption which sets the stage for self-directed change; implementation strategies convert goals into productive actions; and maintenance strategies help to sustain achieved behavioral changes (Maes & Karoly, 2005).

Despite what is known, one of the prevailing limitations in the field of health behavior change is a lack of evidence for a number of assumptions and theories. For example, despite the assumption of their role in change, socio-demographic factors are poor predictors of persons' likelihood to engage in health behavior change (Greene & Yedidia, 2005). Providing factual information alone usually does not lead to the maintenance of behavior change (Bodenheimer, 2005). Understanding and harnessing an individual's health beliefs (e.g., Health Belief Model, Health Promotion Model, and Theory of Reasoned Action) promotes initiation but not long-term maintenance of a health behavior (Nigg, Allegrante, & Ory, 2002). However, there is evidence that this behavior change backsliding has a common pattern. Regardless of the behavior, the highest rate of relapse is seen very early after the change, and this has been observed across behaviors such as dieting, smoking cessation, and increasing calcium intake to promote bone strength (IOM, 2001).

Understanding the activities that individuals undertake to promote and maintain change is a daunting but crucial enterprise. For people who state that they want to make health behavior changes, procrastination and acceptance of the status quo are commonplace (Anderson, 2003). Even when initial gains are achieved, they often wane after the conclusion of an intervention. Therefore, understanding how to maintain these gains over time is vital to promoting sustained health benefits (Ory, Smith, Mier, & Wernicke, 2010). Of the maintenance studies conducted,

many in the area of weight loss, there is clear evidence that few health behavior changes are sustained long-term (Elfhag & Rossner, 2005; Kumanyika et al., 2000; Wing et al., 2008).

Researchers and clinicians are confronted with the realization that health behavior change is a more complex process than originally envisioned. New health behaviors are frequently not maintained, and behavioral outcomes realized in controlled research studies have not been achieved in real-world settings (IOM, 2001). These discrepancies have a significant impact on the health (actual or potential) of the individual and on the health of society at large. Research to date also informs us that there is little known about how people move through the actual process of changing and maintaining health behaviors, and many of the tentative conclusions we have reached are based on retrospective self-reports. Asking individuals to complete measurement tools describing how they conducted health behavior change fails to provide a clearer understanding of a process that would be better gauged if individuals were queried while actually attempting to enact these changes – in other words, asking them "in the moment." Most health behavior change does not occur in a research laboratory or a clinician's office, but is part of an ongoing challenge comprised of thousands of decisions to act or not act, made on a daily basis, over the course of a lifetime.

Background on Ecological Momentary Assessments

A major concern with health promotion and disease prevention research is that retrospective data is not only threatened by random error but is also replete with systematic bias, which can distort recall even after relatively short intervals (Moskowitz, Russell, Sadikaj, & Sutton, 2009). For example, experiences are more likely to be reported if they are emotionally salient or unique, whereas routine experiences are less likely to be recalled and reported at all (Moskowitz et al., 2009). An alternative approach to assessing the process of health behavior

change is using the measurement strategy of Ecological Momentary Assessment (EMA). EMAs are assessments of behaviors, thoughts, feelings, and experiences administered repeatedly and designed to capture real-time data in an unobtrusive manner while participants are carrying out their daily routines in their typical environments (e.g., work, home, school, etc.) (Morren, Dulmen, van Ouwerkerk, & Bensing, 2009). EMAs take the form of a few, simple questions that participants can answer quickly. In contemporary research, EMAs are measured frequently throughout the day (ranging from 1 to 15 questions per day) for a study duration ranging from 1 day to 8 weeks (Stone et al., 1998). In one study (Stone et al., 1998), 95% of participants responded to 88% of the study's EMAs within 2 minutes of receiving them. This innovative method of data collection has been used via handheld PDAs (personal digital assistant) and smartphone devices. EMA measurement tools possess other advantageous characteristics such as minimizing recall bias in participants, improving ecological validity, and increasing the precision of the assessment data obtained. EMAs are the ideal modality in which to rapidly assess real-time behavior changes as they are being carried out by participants.

To date, EMAs have not been applied to the examination of health behavior processes such as self-regulation, nor have they been applied to capture responses to disease prevention interventions. Previous research has concentrated on using EMAs to collect physiological data (e.g., blood pressure, heart rate), report symptomology (e.g., rate pain on a 0 to 10 pain scale), or indicate discrete events associated with a variety of treatment programs or conditions such as relapse among alcoholics, drug use among narcotics abusers, binge-eating episodes among those suffering from bulimia nervosa (Anestis et al., 2010; Morren et al., 2009; Poulin et al., 2010; Runyan et al., 2013).

Although there are a variety of positive utilities for EMA, there are also some

methodological considerations when designing studies. Shiffman (2009) identifies several of these concerns throughout his vast work in the development of EMA. First, he states that reactivity could be an area of concern. Reactivity is defined as the potential for behavior experience to be affected by the act of assessing it (Shiffman, 2009). Compliance can also be an issue as people are required to complete assessments in a timely fashion (Shiffman, 2009). Failure to complete these assessments can bias the results especially if the missing data are nonrandom (Shiffman, 2009).

Ecological Momentary Assessment Sampling Schedules

In regards to EMA measurement strategies, there are three primary sampling design structures, with variations and combinations of each: time-contingent, signal-contingent, and event-contingent (Moskowitz et al., 2009). EMA measures that are time-contingent are taken at fixed points throughout the day (e.g., 9 a.m., noon., 5 p.m.; once, at the end of the day, every day, for several weeks). When there are a fixed number of measures per day that are completed in response to randomly scheduled signals, this is know as a signal-contingent design. In event-contingent designs, EMA measures are completed when a particular kind of event, designated by the investigator, occurs (e.g., an unhealthy behavior such as smoking a cigarette, drinking alcohol to excess, purging food for an individual with bulimia nervosa). The event-contingent design allows the collection of data about events that might be missed with time-contingent or signal-contingent designs. There are variations in the designs including combinations approaches (e.g., combining signal-contingent with fixed-interval schedules).

To date, sampling approaches are typically made with reference to the goals of the assessment and the nature of the construct to be measured (Collins, 2006). Daily recording is most appropriate for the measurement of constructs that occur relatively infrequently (or change

slowly) and that are sufficiently salient and discrete to be recalled and reported on accurately within a 24-hr period (Moskowitz et al., 2009). Multiple measurements per day are typically required for the adequate assessment of constructs associated with frequent and rapidly changing constructs, especially when measurement is highly susceptible to retrospective biases (Moskowitz et al., 2009).

Sampling frequency and duration of the sampling period are aspects of EMA designs characterized by great variability and minimal standardization across studies. A systematic review of EMA studies assessing nutrition and physical activity analyzed thirteen studies, considering five methodological issues: 1) sampling and measures, 2) schedule, 3) technology and administration, 4) prompting strategy, and 5) response and compliance. The majority of studies (69%) monitored their participants during one period of time, although the monitoring period ranged from 4 to 14 days, and EMA sampling frequency ranged broadly from 2 to 68 times per day (Liao, Skelton, Dunton, & Bruening, 2016). Although there has been some categorization of EMA study designs in terms of the trigger for EMA sampling (e.g., a particular event or signal as compared to a fixed interval), there remains a broad range of possibilities in terms of the length of the sampling period and the number of times participants are sampled on any particular study day.

Study Significance for Health Behavior Change Research, Osteoporosis, and Nursing

Despite their best intentions, individuals are oftentimes unsuccessful in starting and maintaining health behavior changes. People find themselves trapped in this so-called "intention-behavior-gap" (Sheeran, 2002), which has been empirically measured for behaviors like physical activity (Sniehotta, Scholz, & Schwarzer, 2005) and cancer-screening (Sheeran & Orbell, 2000). This difficulty in successfully starting and maintaining behavior change suggests

that health behavior research itself is failing to provide insight and direction regarding how lasting change is achieved. The current study offers a new approach to investigating the process of health behavior change to further develop this science and aid people in realizing their health behavior goals.

The current study contributes significantly to health behavior research because it: (a) focuses on the prevalent and costly health condition of osteoporosis; (b) has applicability beyond osteoporosis to a variety of chronic health conditions that individuals and health professionals are confronting worldwide; and (c) utilizes the real-time measurement strategy of EMAs to describe the complex, dynamic activities involved in a theory-based, behavior change process. Although EMAs have been used in the last few decades to measure behaviors, symptoms, and mood states, they have not yet been applied to measuring a process such as self-regulation.

Osteoporosis, a condition characterized by compromised bone mass quality and increasing bone fragility, presents a major health care challenge. It is the most common bone disease in the world (National Osteoporosis Foundation [NOF], 2011). Approximately one in two Caucasian women will experience an osteoporosis-related fracture at some point in their lifetimes (Burge et al., 2007), and prevalence is increasing most rapidly among women of color. In the United States alone, costs for care of osteoporosis and associated fractures over the next two decades will reach $474 billion (NOF, 2011). Osteoporosis-related fractures bring a burden of acute and chronic pain; decreased independence; lowered self-esteem related to disfigurement; and disability, resulting in time lost from work or the inability to perform activities of daily living.

There is consensus among a global community of experts regarding interventions to help prevent osteoporosis (Ryan, Maierle, Csuka, Thomson, and Szabo, 2013). However, the

majority of women worldwide fail to engage in osteoporosis protective behaviors including good nutrition; appropriate intake of calcium; regular engagement in physical activities; exercises targeted at restoring balance and building bone; and obtaining bone density screenings (Ryan et al., 2013). A number of the behavior recommendations associated with osteoporosis prevention (e.g., healthy nutrition, regular physical activity) are relevant to other chronic conditions such as cardiovascular diseases and type 2 diabetes. Therefore, understanding health behavior change for osteoporosis prevention has applicability to a variety of health conditions that advocate for adopting and maintaining similar kinds of health behaviors.

The current study used data obtained as part of a larger study testing the efficacy of an m-Health intervention (Ryan et al., 2018). The current study focused on a subset of participants in the primary study receiving the intervention (discussed in greater detail in the Design section).

Table 1

Description of Self-Regulation Activities (Ryan, 2009)

Self-Regulation Activities	*Description*
Goal-setting	Goals for behavior change should be self-directed, feasible in the selected time frame, specific, self-monitored, and measureable
Self-monitoring	Refers to tracking one's own behavior. This data will eventually be used to evaluate progress towards a goal
Reflection	Thinking about what one has learned through goal-setting and self-monitoring and gaining insight into progress made or not made towards a goal, with the eventual result of deciding what action to take next
Decision-making	Selection of a plan of action from available alternative scenarios
Planning	Specific instructions of "who," "when," "where," and "how" a behavior is to be performed
Self-evaluation	Using the information gathered through self-monitoring to determine progress towards achieving individual goals
Emotional Control	Controlling feelings associated with the behavior change process such as anger, frustration, hopelessness, apathy, boredom, etc.

The current study examined whether or not a theoretically-derived process (i.e., self-regulation) was actually used by individuals to initiate health behavior change. The activities that comprise the self-regulation process are summarized in Table 1. For each of the theorized self-regulations activities, a description of that activity is provided. The descriptions are derived from the conceptualization of each self-regulation activity as presented in two contemporary health behavior change theories that serve as frameworks underpinning the current study. These descriptions were used by the primary study research team to operationalize each self-regulation activity in the form of EMA response options.

The current study's analysis was accomplished using EMAs that measure self-regulation activities used by participants in real time and in ecologically valid, community settings (e.g., at work, home, school). The proximal outcome assessed in this study was the self-management behavior participants reported engaging in, namely, increasing calcium intake, increasing physical activity, increasing strength, and increasing balance. Although the population of interest is midlife women and the condition of focus is osteoporosis, understanding use of the self-regulation process and its potential outcomes has generalizability to diverse populations with a variety of chronic health conditions.

The current study can make a significant scientific contribution to understanding the initiation of health behavior change by advancing our understanding of the self-regulation process. The findings could potentially catalyze future self-regulation investigations including: development, testing, and implementation of a measurement tool for self-regulation; and, eventually, intervention development based on a clearer understanding of the self-regulation process, as actually used by individuals.

Much of nursing research attempts to understand how best to promote health behavior

change (Conn, 2011). Such descriptive, predictive, and evaluative research examines the relationships between behavioral, cognitive, emotional, and environmental factors and links these to disease states with the aim of providing better preventive or treatment services. Nursing research often uses rather general, retrospective measurement tools, such as questionnaires or interviews. These methods may not capture the phenomena of interest well, if at all. The EMA measurement strategy captures events that are part of nursing practice that are difficult to reproduce in laboratory settings, such as behavior changes that occur in real-world environments (e.g., taking blood pressure medications as prescribed, monitoring blood glucose levels and responding to them appropriately, engaging in regular aerobic activity).

The knowledge garnered from analysis of EMA data measuring the health behavior change process may influence not only the design of theory-driven nursing interventions, but clinical practice as well, including: avoiding generalized, over- and under-reporting of health behaviors, linking environmental and social factors with signs and symptoms, allowing measurement and tracking of variations in health and health behaviors over time, and providing new opportunities for patient self-monitoring and increased awareness regarding disease process (e.g., circumstances preceding condition exacerbations, high risk behaviors, etc.). Nurses working in a variety of healthcare environments with diverse patient populations are ideally positioned to helping individuals adopt lifestyle changes whether it be for health promotion, acute recovery, or chronic condition management. This study could help illuminate how best to assist individuals in undertaking and maintaining health behaviors.

Theoretical Background: Integrated Theory of Health Behavior Change (ITHBC)

The ITHBC is a mid-range, descriptive nursing theory that proposes health behavior change can be fostered by promoting knowledge and beliefs, enhancing social facilitation, and

increasing self-regulation activities (Ryan, 2009). According to ITHBC, people are more likely to engage in the recommended health behaviors if they have knowledge about and maintain health beliefs consistent with the behavior, if they experience social facilitation that positively influences and supports them to engage in health behaviors, and if they develop and practice self-regulation activities to change their health behaviors (Ryan, 2009). Knowledge and beliefs impact behavior-specific self-efficacy, outcome expectancy, and goal congruence (Ryan, 2009). Social facilitation includes social influence, social support, and negotiated collaboration between individuals, families, and healthcare professionals (Ryan, 2009). Self-regulation is the process used to change health behavior and includes activities such as goal-setting, self-monitoring and reflective thinking, decision making, planning for and engaging in specific behaviors, and self-evaluating physical, emotional, and cognitive responses associated with health behavior change (Ryan, 2009). The ITHBC theory is predicated on the assumption that health behavior change is a dynamic, iterative process that requires desire and motivation to change on the part of the person enacting that change (Ryan, 2009).

The focus of the current study was a description of the self-regulation process as presented in Ryan's (2009) ITHBC (see "Self-Regulation skills and abilities" outlined by the solid, black box in Figure 1), and later included in Ryan and Sawin's Individual and Family Self-Management Theory (Ryan & Sawin, 2009). According to Ryan's (2009) ITHBC, a proximal outcome of self-regulation is self-management behaviors (see "Proximal outcome" outlined by a dashed box in Figure 1), and the current study included a description of a self-management behavior based on participant EMA responses (self-reported increases in the osteoporosis prevention areas of calcium, balance, strength, and physical activity).

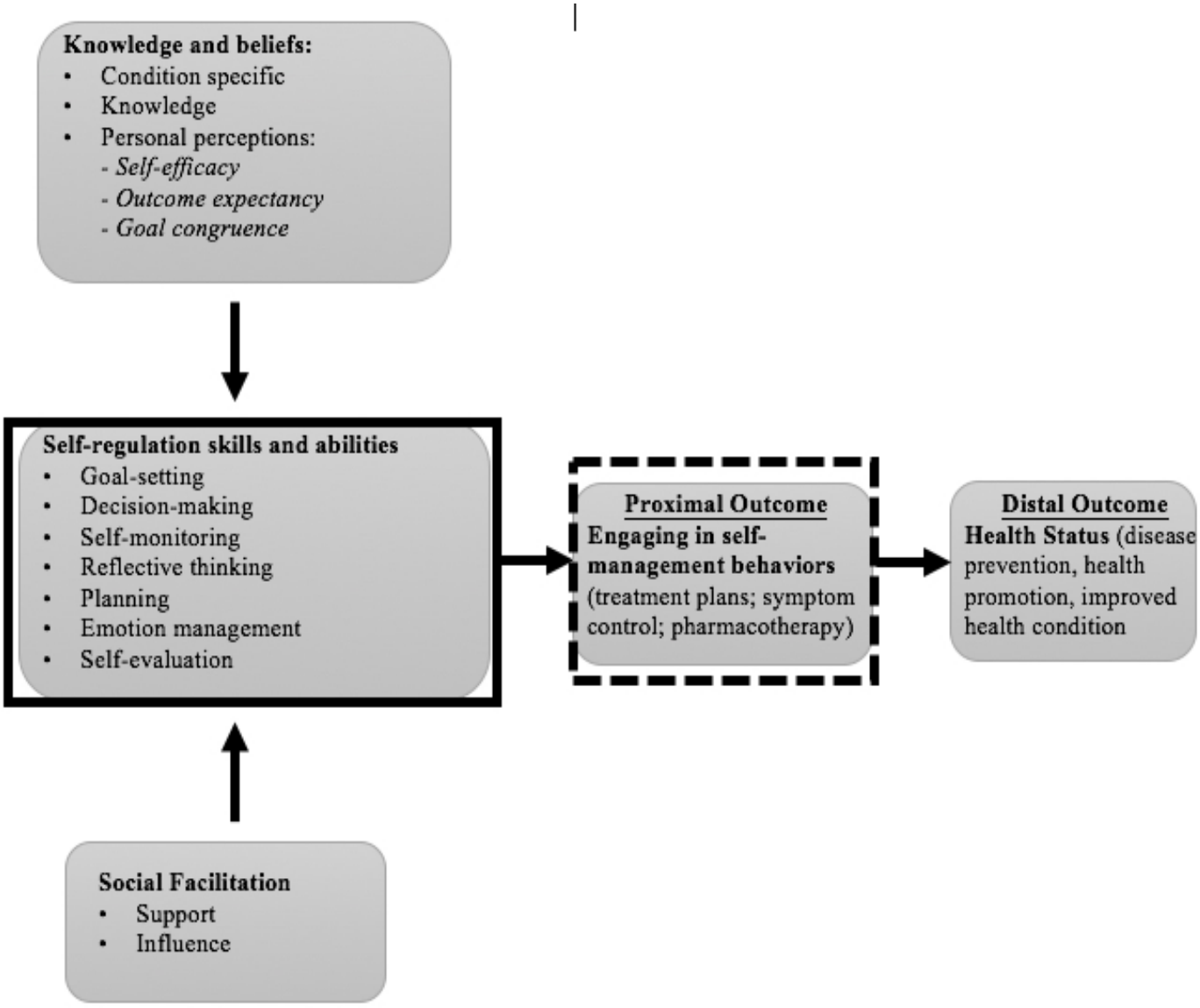

Figure 1. Integrated Theory of Health Behavior Change (Ryan, 2009)

Once an individual recognizes that a health behavior needs to change, self-regulation includes the activities undertaken by that individual to realize that behavior change. Little research has been conducted that successfully aids scientists and clinicians in understanding the extent to which theory-based, self-regulation activities are used by individuals to pursue their health goals. Clearly, health behavior change is more complex than following a standardized behavioral regimen. Understanding the actual self-regulation activities utilized in pursuit of health behavior change is the knowledge gap that the current study addressed.

Habit Formation and Health Behavior Change

To date, interventions to change health behaviors have demonstrated limited success at establishing enduring lifestyle modifications. Despite successfully increasing people's knowledge and favorable intentions to adopt healthy behaviors, interventions typically induce only short-term behavior changes. For those interventions that are able to promote change, that change is typically not maintained over time. A study by Wood and Neal (2016) reviewed the results of high quality health behavior change intervention studies. Across dozens of studies, they identified a triangular relapse pattern in health behavior change over time – participants had an initial spike in behaviors during the interventions period followed by a decline back to baseline after the intervention ended. This pattern was identified across a variety of health behaviors including weight loss, exercise, gym visits, and smoking cessation.

A growing body of literature suggests that habit-formation principles are key components in moving individuals from merely initiating behavior change to actually maintaining that change in the long-term. 'Habits' are defined as actions that are triggered automatically in response to contextual cues that have been associated with their performance. For example, automatically washing hands (action) after using the toilet (contextual cue), or putting on a seatbelt (action) after getting into the car (contextual cue). Decades of psychological research consistently show

that mere repetition of a simple action in a consistent context leads, through associative learning, to the action being activated upon subsequent exposure to those contextual cues (that is, habitually). Once initiation of the action is 'transferred' to external cues, dependence on conscious attention or motivational processes is reduced. Therefore, habits are likely to persist even after conscious motivation or interest dissipates. Habits are also cognitively efficient, because the automation of common actions frees mental resources.

When trying to determine the length of time required before a health behavior change has entered a maintenance phase, it is useful to consider health studies that look at time to habit formation. Participants in a study by Lally, Van Jaarsveld, Potts, and Wardle (2010) repeated a self-chosen health-promoting behavior (for example, eat fruit, go for a walk) in response to a single, once-daily cue in their own environment (such as, after breakfast). Daily ratings of the subjective automaticity of the behavior (that is, habit strength) showed an initial acceleration that slowed to a plateau after an average of 66 days. Lally et al. (2010) concluded that, on average, it takes more than 2 months before a new behavior becomes automatic. However, how long it takes a new habit to form can vary widely depending on the behavior, the person, and the circumstances. In Lally's study, it took anywhere from 18 days to 254 days for people to form a new habit.

Self-Management and Self-Regulation

The concept of self-management first appeared in a book by Thomas Creer on the rehabilitation of children with chronic illnesses. Creer and colleagues used the concept to indicate that the patient was an active participant in his or her care. Creer and Holyroyd (1997) state that self-management differs from adherence in that "self-management places greater emphasis on the patient's active role in decision-making, both inside and outside the consultation room" (p.8). Self-management is also viewed as being distinct from disease management, which

Creer and Holyroyd view as more the emphasis of healthcare professionals' algorithms and interventions to standardize care as opposed to self-management, which emphasizes the patients' involvement in defining and solving health-related problems and making health behavior changes.

Looking across self-management theorists and researchers (Kralick, Koch, Price, & Howard, 2004; Lorig & Holman, 2003; Ryan & Sawin, 2009), it is readily discernible that one or multiple aspects of self-regulation appear embedded in their descriptions of self-management. Lorig and Holman's (2003) five core self-management skills include problem-solving, decision-making, and taking action, strategies described in the concept analysis of self-regulation (Manuscript 1). Kralick et al.'s (2004) qualitative study of participants with a chronic disease asked them to describe self-management. Participants characterized self-management as a process that includes dimensions of self-regulation such as monitoring, planning, and prioritizing. According to Ryan and Sawin (2009), self-management refers to three different phenomena: a program, an outcome, or a *process*, with self-regulation being a part of the *process* of changing health behaviors.

Despite the description of self-regulation as embedded within self-management that is evident in the literature, Ryan's (2009) ITHBC delineates the self-regulation process as activities that can culminate in the proximal outcome of self-management behavior. Self-management behavior refers to what the individual *actually does* (e.g., increasing physical exercise, improving nutritional intake), which captures the immediate consequence of successfully engaging in the self-regulation process. All of the planning, self-monitoring, emotional control, decision-making, and so forth, are carried out with the intention of doing something different – modifying an existing self-management behavior or engaging in an entirely new one.

Purpose and Research Questions

Self-regulation research informs health behavior change programs and interventions developed by scientists and healthcare professionals. Clinicians in health-related fields stand to benefit from a cohesive understanding of the self-regulation concept and clarification of how self-regulation activities are used across varied contexts and perspectives. Ryan (2009) laid conceptual groundwork by describing self-regulation activities and self-management behaviors in the ITHBC.

Purpose. The purpose of the current study was to describe, in depth, the osteoporosis prevention areas, self-regulation activities, and self-management behaviors reported by intervention group participants during the initiation of health behavior change.

Research Question 1. During the initiation phase of behavior change, are there differences in participants' reported engagement in osteoporosis prevention areas (calcium intake, strength, balance, and physical activity) in response to EMA sampling?

Research Question 2. During the initiation phase of behavior change, are there differences in participants' reported use of self-regulation activities (e.g., goal-setting, planning, self-monitoring) in response to EMA sampling?

Research Question 3. During the initiation phase of behavior change, are there differences in participants' reported achievement of self-management behaviors (e.g., increasing calcium intake, balance, strength, or physical activity)?

Inconsistencies in Self-Regulation: Opportunities for Conceptual Clarity

Though Ryan (2009) and Ryan and Sawin (2009) presented a version of self-regulation in their respective theories, there is a lack of consensus among theorists and researchers regarding defining self-regulation and the constituent activities comprising the process. At the very root of confusion regarding self-regulation one need look no further than the fact that the concept itself

is defined in a variety of ways by those attempting to investigate it, when the concept is defined at all. Self-regulation is defined by Springvloet, Lechner, and Oenema (2014) as the capacity to regulate and adapt behavior in order to achieve self-set goals. Taylor, Bagozzi, and Gaither (2005) define self-regulation as the mental and physical processes that a person manages in order to achieve a goal. Social cognitive theorists, such as Bandura (1991), have defined self-regulation as thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals. The current study defined self-regulation as a self-directed process consisting of self-regulation activities pursued to meet a particular goal (i.e., achieving a self-management behavior such as increasing calcium intake, physical activity, strength or balance). The derivation of this definition is from the analysis conducted in Manuscript 1 "Concept analysis of self-regulation in health behavior change."

The assumption that self-regulation is a concept aimed at moving an individual toward personal goal achievement is common across definitions. However, the lack of a consistent, cohesive definition becomes problematic for those seeking to investigate the concept or design interventions based on it. For example, some researchers and theorists consider self-regulation to be a trait, inherent to an individual's character and unlikely to be altered. In this conceptualization, how can interventions aimed at altering self-regulation be conceivably developed and employed with any hope of success? Alternatively, there are studies that refer to self-regulation as a resource that an individuals access when pursuing a goal. However, considering self-regulation to be a resource suggests that it can be depleted and replenished, while failing to explain how and when these circumstances occur. This topic of defining self-regulation is revisited in Manuscript 1, where a literature review and analysis are conducted to define self-regulation and describe its antecedents, attributes, and consequences.

Whether self-regulation is defined as resources, traits, or activities, an additional problem emerges in the literature which obfuscates the concept – namely, the core components of self-regulation vary from study to study. For example, a study testing the efficacy of a self-regulation intervention developed for patients with chronic obstructive pulmonary disease reported using three elements of self-regulation theory, self-monitoring, self-judgment, and self-reaction, without specifying which self-regulation theory authors were adhering to or defining the three components included in the intervention (Kuo et al., 2013). Dorough et al. (2014) developed a self-regulation intervention to utilize with pre-hypertensive adults. Their intervention focused on self-regulation activities identified as planning, goal-setting, and tracking. A study by West and Hastings (2011) exploring physical activity in adults measured self-regulation factors, which were identified as self-efficacy, control, and active engagement in physical activity training. A trend that quickly emerges in the literature is the variety of components that are termed as being "self-regulatory" even for studies conducted in the same discipline. Indeed, one hypothesis for this variation is that different theoretical backgrounds are being used to develop these self-regulation interventions. However, of the three studies cited above, all of them claimed to use a social-cognitive theoretical basis to shape their view of self-regulation.

Although evidence generally supports the notion that self-regulation is multidimensional and critical for attaining goals, as discussed above, considerable debate remains about its definition and specific components. Therefore, one of the top priorities for self-regulation researchers should be to pursue clarification of the concept. A review of literature published in the past two decades reveals no such undertaking, yet a conceptual analysis of self-regulation may aid in determining the attributes, antecedents, and consequences of self-regulation in health behavior change and identify the relationships between these variables, if any exist.

Another means of clarifying and better understanding self-regulation is to see how the

concept operates in the real world. The situational specificity that influences our ability to self-regulate health behavior is difficult to artificially create and measure in a laboratory setting. Health behaviors are pursued in the real world – at school, work, and home – surrounded by social and environmental forces that cannot easily be artificially contrived. Nor can this ongoing process always be accurately measured using retrospective, single occasion, self-report measures. A study design where participants are asked once, at the end of the study, to recall the process of how they went about making change is subject to retrospective and heuristic biases that obscure the behavior change experiences that occurred. An alternative design that queries participants throughout the day, as they go about their routines, on what self-regulation activities they are engaged in is far more likely to develop an accurate and ecologically valid description of the concept. Despite the fact that self-regulation is a *process*, process measurement tools have been used infrequently to describe this phenomenon in behavior change and health-related literature. Health behavior change researchers currently lack an *empirical* description of self-regulation. Therefore, investigators, especially those designing self-regulation intervention studies, are attempting to alter health behavior change without a clear understanding of how this process is actually occurring.

Measurement of health behavior change to date has focused on outcomes and utilized retrospective, self-report approaches. However, the process of health behavior change requires measurement tools that make transparent the activities of the process and their variability over time. Ecological Momentary Assessment provides an innovative approach to describing the activities of the health behavior change process as it provides data that occur in real-time and in community settings (Baumeister & Vohs, 2004; Blankers, 2008; Boekaerts, Pintrich, & Zeidner, 2000). In the current study, secondary analysis of EMA data collected during the course of the first three months of a year-long interventional study was used to describe the initiation of

behavior change and engagement in the self-regulation process. Analysis of EMAs has the potential to make a major contribution to comprehending the process people use to make health behavior change. Understanding the use of self-regulation by individuals in the real world will facilitate identification of critical self-regulation activities that direct health behavior change and the realization of self-management behaviors.

Structure of Dissertation

This dissertation was based on the manuscript option and includes three manuscripts:

- Chapter 1: Concept analysis manuscript of self-regulation using Walker and Avant's (2011) concept analysis process entitled "Concept analysis of self-regulation in health behavior change"
- Chapter 2: Systematic review of self-regulation interventions entitled "Systematic review of self-regulation interventions targeting health behavior change"
- Chapter 3: Research design and methods for descriptive dissertation study
- Chapter 4: Results manuscript of secondary analysis of EMA data entitled: "Understanding the self-regulation process using Ecological Momentary Assessments"
- Chapter 5: Synthesis of the results including contributions to health behavior fields and the implications for practice, policy, and future research

Manuscript 1

The first of three manuscripts in this dissertation is a concept analysis of self-regulation. This manuscript will be submitted to the peer-reviewed journal *Nursing Forum* for consideration. The manuscript is written according to the author guidelines provided at the journal's home website. It is written according to the Publication Manual of the American Psychological Association (APA) Sixth Edition (2010) reference and citation requirements.

Manuscript 1

Title: Concept Analysis of Self-Regulation in Health Behavior Change

Abstract

Theoretical descriptions of self-regulation present the concept as a behavior change process involving individuals setting specific, personally-meaningful goals and employing a variety of skills and abilities to achieve said goals. The author observed that, as applied to health behavior change, self-regulation is inconsistently defined and there is wide variability in terms of which skills and abilities fall within the scope of self-regulation. The aim of the present concept analysis is to describe and analyze the self-regulation concept using Walker and Avant's (2011) framework. Four databases were searched (1976-2018) using the terms 'self-regulation' or 'self-regulatory' in the title combined with 'health behavior change' and 'goal' in the text of the article. Attributes of self-regulation identified from the literature include goal-setting, planning, self-monitoring, performance assessment, and self-efficacy. Antecedents identified were pre-action self-efficacy, outcome expectancy, risk assessment, and motivation. Consequences included three categories: health-related, process-related, and psychological. 'Crossovers' was a term developed by the author to describe components of self-regulation that transcended antecedents, attributes, and consequences and were applicable at multiple points of the self-regulation process. Crossovers components of self-regulation identified include self-efficacy, self-control, and information gathering. Defining self-regulation, including attributes, consequences, antecedents, and referent cases, has the potential to assist healthcare professionals as the collaborate with clients engaging in self-regulation.

Introduction

Human beings are unique among living creatures in their abilities to control emotional states, inner cognitions, and outward behaviors. However, despite our abilities to resist impulses in the service of goal pursuit, behaviors that jeopardize our health status are surprisingly difficult to change. Poor diets, smoking, risky sexual activities, and physical inactivity are habits that persist despite intentions to modify them, and these behaviors claim millions of lives each year. Eating a healthy diet, increasing physical activity, and avoiding tobacco use could prevent 80% of premature heart disease, 80% of type 2 diabetes cases, and 40% of cancers (World Health Organization [WHO], 2004).

Between the decision to make a health behavior change and the achievement of that change, there are a number of theorized processes that individuals conceivably perform. One such process is known as self-regulation, which is defined by Carver and Scheier (1998) as the efforts people dedicate to change their thoughts, feelings, and impulses in the pursuit of their goals. Central to most self-regulation theories is the idea that "individuals live life by identifying goals and behaving in ways aimed at attaining those goals" (Scheier & Carver, 2003, p. 17).

Although evidence generally supports the notion that self-regulation is multidimensional and critical for attaining goals, considerable debate remains as to the concept's exact definition and specific components. Inconsistent descriptions of self-regulation have been employed within the realms of health behavior theory and empirical research. Ongoing ambiguity exists regarding the defining characteristics, antecedents, attributes, and consequences of self-regulation.

The purpose of this concept analysis is to use Walker and Avant's (2011) framework for concept analysis to describe and analyze self-regulation. Clarification of self-regulation will enhance communication within and among disciplines focused on promoting health behavior change, such as nursing. Understanding self-regulation enables nurses to identify and promote

the process activities in which patients engage as they strive to initiate behaviors and achieve goals related to health such as starting a physical activity program, modifying detrimental eating habits, or abstaining from an unhealthy behavior (e.g., smoking, alcohol abuse). Nurses can utilize knowledge of self-regulation to assess, provide feedback, and support patients as they endeavor to change behavior and maintain change. Improved comprehension of the self-regulation will also guide nurse researchers in developing interventions to promote and instruments to measure the concept.

Background on Self-Regulation

Psychologists beginning in the late 19th century presented a variety of perspectives on the nature of processes that form the foundation of human behavior. The trait-disposition, biological, and learning theory perspectives that dominated thinking about motivation and behavior for the majority of the 20th century all shared the assumption that behavior was mostly the result of non-reasoned processes (De Ridder & De Wit, 2006). Only more recently have scholars started incorporating human agency and begun addressing the ways in which motivation and cognition are linked (Mischel, Cantor, & Feldman, 1996). This evolving perspective is perhaps best exemplified in Bandura's (1977) assertion that cognitive processes play a pivotal role in human learning as well as motivation. An important cognitive process underlying motivation is that reinforcements create expectations about future outcomes, which guide behavior through the processes of goal-setting and self-evaluation against personal standards, an idea that has become central to many self-regulation perspectives of behavior (De Ridder & De Wit, 2006).

Although self-regulation has it beginnings in psychology, where it was applied by clinical psychologists to steer patients towards achieving their behavior change goals, the fields of healthcare and nursing provide unique opportunities for the application of self-regulation as well.

Nurses consistently witness the marked discrepancies that exists between the health behavior goals that people set for themselves and the repeated failure to achieve or maintain these changes. Certain nursing interventions appearing in contemporary literature are closely tied to self-regulation. For example, motivational interviewing (MI) is an intervention that can involve a healthcare professional trying to identify a patient's beliefs and values and assist them in recognizing inconsistencies between their current health goals and behaviors and present health status (Marques, Gucht, Leal, & Maes, 2015). Components of self-regulation including goal-setting, decision-making, and self-evaluation are recognizable in the nurse-patient motivational interviewing process (Babler & Strickland, 2016). Therefore, although these interventions are not always labeled by researchers as 'self-regulation interventions,' it is evident that nursing is utilizing self-regulation to inform interventions that promote health behavior change. However, as previously mentioned, how self-regulation is defined and described remains quite fluid, making understanding and communicating about the concept challenging.

Method

Concept analysis is one means of clarifying vague concepts and distinguishing similar concepts from one another. Although several methods of analysis exist, this report uses the concept analysis described by Walker and Avant (2011) to analyze self-regulation. The method was chosen for its ease of use, step-by-step approach, and widespread application to concepts relevant to nursing (Lusk & Fater, 2013; Heslop & Lu, 2014). The method described by Walker and Avant (2011) consists of eight steps that may or may not be conducted in a linear fashion (Figure 1).

Walker and Avant (1995) noted that, because concepts evolve over time, concept analysis "should never be viewed as a finished product" (p. 37). They emphasize the significance of examining research beyond one's own discipline to determine all uses of a concept. Therefore,

an effort is made in this analysis to include literature published over the last four decades in nursing, medicine, psychology, and education.

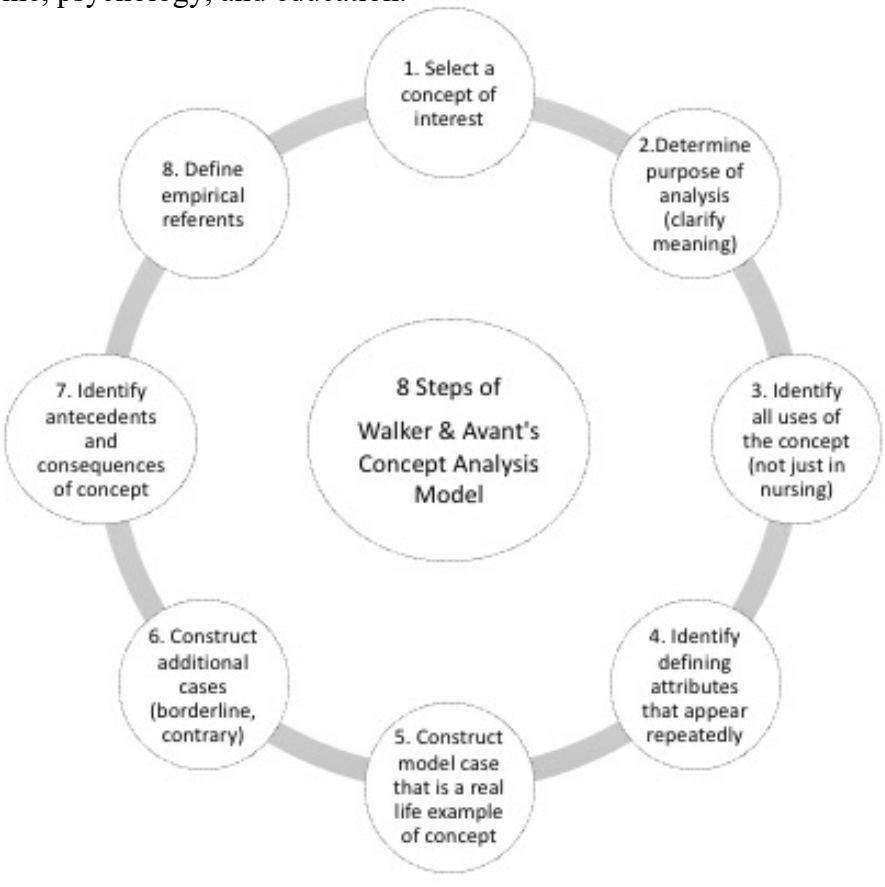

Figure 1. Walker and Avant's concept analysis model (2011)

Search Strategy

A systematic search strategy was employed to comprehensively identify all studies relevant to developing a clearer understanding of the self-regulation concept. The EBSCO search interface was employed to query the Cumulative Index of Nursing and Allied Health Literature (CINAHL), Medical Literature Analysis and Retrieval System Online (MEDLINE), Educational Research Information Clearinghouse (ERIC), and Psychological Information Database (PsychINFO) electronic databases. Each resource was queried using the following terms: 'self-regulation' or 'self-regulatory' in the title combined with 'health behavior change' and 'goal' in the text of the article. This was done to focus the search on only those articles that

dealt with the self-regulation concept as it related to health behaviors. Following other authors in the field of self-regulation (Carver & Scheier, 1998; Mischel et al., 1996), including 'goal' as a search term was justified because all self-regulation theories emphasize the volitional processes of goal striving (De Ridder & De Wit, 2006). A targeted, hand search of the bibliographies of papers meeting our inclusion criteria was also conducted to identify additional relevant studies. In addition to these criteria, articles were included if they were: (a) written in the English language and published between 1976 and 2018; (b) included adult subjects only (age 18 and older); (c) contributed to understanding the concept of self-regulation; (d) contributed to the definition, attributes, antecedents and/or consequences of self-regulation. The initial search including the terms listed above yielded 1,684 articles (see Figure 2). Although this review of literature is not a systematic review or meta-analysis, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were used to present search results in an organized and logical manner (Moher, Liberati, Tetzlaff, & Altman, 2009). Titles and abstracts were reviewed by hand and the following were excluded: duplicate articles, non-adult subjects (e.g., adolescents, toddlers, children), articles focused on self-regulation as it related to ethical standards of practice, and articles that included the terms 'self-regulation' or 'self-regulatory' but did not included attempts to define or delineate attributes of the concepts.

Of the 18 studies included in this review, seven were randomized control trials (Annesi, 2011; Baptist, Ross, Yang, Song, & Clark, 2013; Ginis & Bray, 2010; Kalichman et al., 2011; Kuo et al., 2013; Lange et al., 2013; Marques, Gucht, Leal, & Maes, 2015), nine were either cross-sectional or quantitative but non-randomized designs (e.g., time series designs) (Butson et al., 2014; Hofmann, Finkel, & Fitzsimmons, 2015; Koring et al., 2013; Luszczynska & Schwarzer, 2003; McKee & Ntoumanis, 2014; Milyavskaya, Inzlicht, Hope, & Koestner, 2015; Scholz, Sniehotta, Burkert, & Schwarzer, 2007; Schuz, Wurm, Warner, Wolff, & Schwarzer,

2013; van Osch et al., 2010;), one was qualitative (McKee, Ntoumanis & Smith, 2013), and one was a description of an intervention (Plaete, Bourdeaudhuij, Verloigne, Oenema, & Crombez, 2015).

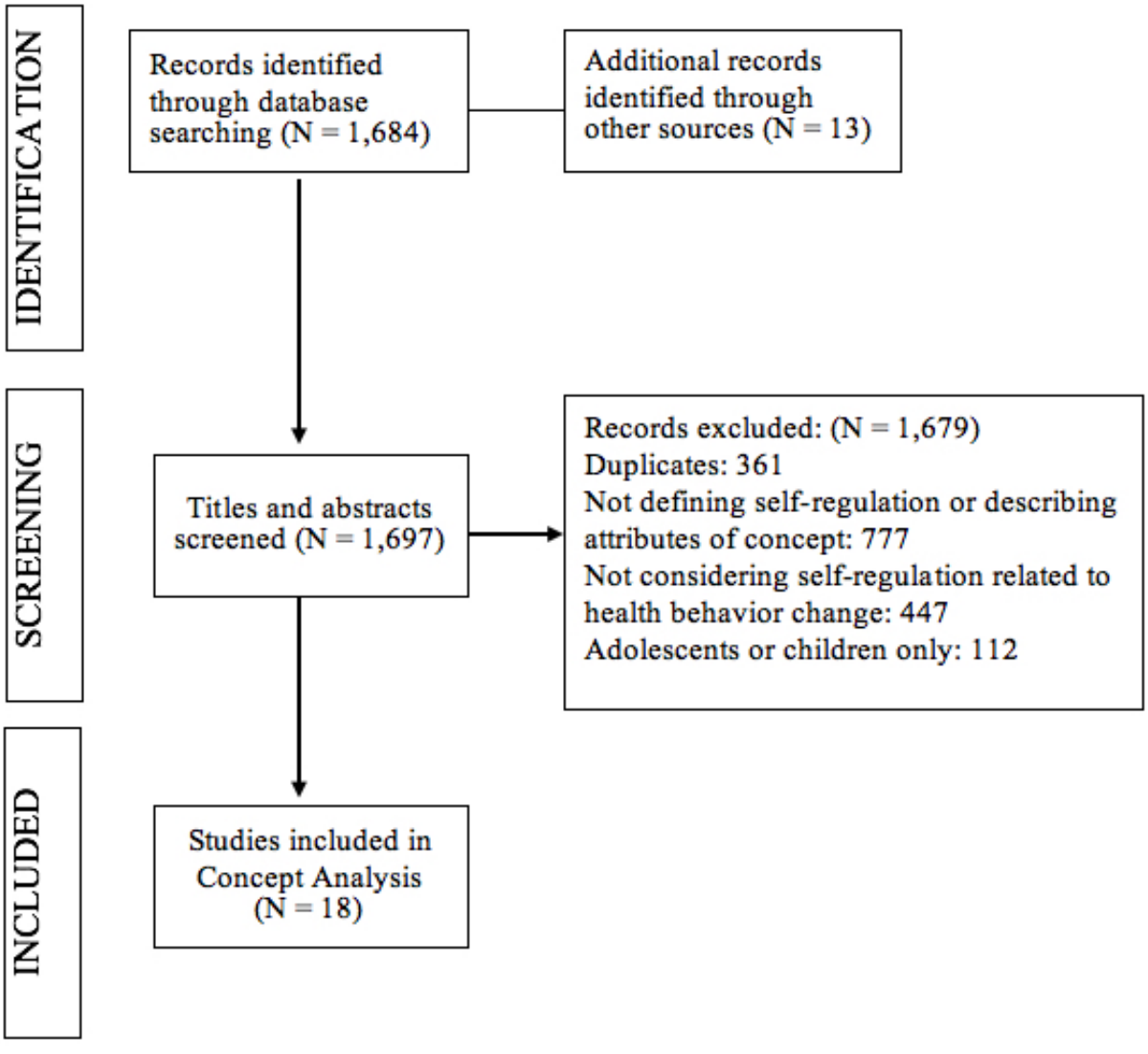

Figure 2. PRISMA-based flow of studies for concept analysis

Table 1

Review of Self-Regulation Antecedents, Attributes, and Consequences

Author, Date	Study Focus, Method	Theoretical Basis	Study Format & Sample	Antecedents (Ant)/Attributes (Att)/Consequences (Conseq)	Conclusions
Annesi (2011)	Quantitative: single group, intervention study; assess a behavioral treatment for obesity (controlled eating, exercise, weight loss); intervention emphasizes short-term goal-setting to increase self-efficacy and instruction in self-regulatory skills	Social cognitive theory presented as basis for intervention	Adults with class 2 and 3 obesity (N = 183) volunteered for 26-week nutrition and exercise treatment; focused on self-efficacy and self-regulation applied to increasing cardiovascular exercise and fruit and vegetable consumption Intervention consisted of exercise support including six 1:1 meetings over 6 months with exercise specialist; computer-based instruction in self-regulatory methods:	Att: **Long- and short-term Goal setting** Att: **Exercise planning** Att: **Recording incremental progress** Att: **Cognitive restructuring** Att: **Stimulus control** Att: **Relapse prevention** (preparing for barriers and recovering from lapses) Conseq: **Fruit and vegetable consumption**	Improved self-efficacy for controlled eating significantly predicted increased fruit and vegetable consumption. Improved self-efficacy for exercise significantly predicted increased exercise When changes in self-regulatory skill usage were stepped into 2 previous equations, variances accounted for significantly increased
Baptist et al. (2013)	Quantitative: blinded randomized control trial; Asthma intervention	Bandura's social cognitive theory of behavior change	70 adults, aged 65 and older with persistent asthma Intervention: six-session program conducted over the telephone and in group sessions Participants selected an asthma-specific goal, identified problems, and addressed potential barriers	Att: **Self-selected** asthma-specific **goal** Att: **observed and researched routine** to see how is was preventing goal achievement Att: developed a **plan** to achieve goal Conseq: **Asthma control, healthcare utilization**	Self-regulation intervention improved asthma quality of life, asthma control, and healthcare utilization
Butson et al. (2014)	Mixed-method, cross-sectional,	In background section, study	36 parents with preschool-aged children	Att: **Receiving relevant information**	Mothers' self-regulation associated with receiving

Table 1

Review of Self-Regulation Antecedents, Attributes, and Consequences

Author, Date	Study Focus, Method	Theoretical Basis	Study Format & Sample	Antecedents (Ant)/Attributes (Att)/Consequences (Conseq)	Conclusions
	non-experimental design; explore which aspects of self-regulation are associated with different categories of physical activity (PA) in mothers and fathers.	makes reference to theories related to goal pursuit and self-regulation (Social Cognitive Theory and Theory of Planned Behavior)	interviewed about their PA and their family's PA. Parents also completed PA and self-regulation questionnaires and wore an accelerometer for five days Self-regulation assessed using a questionnaire (SRQ)	Att: **Evaluating the information and comparing it to norms;** Att: **Triggering change** Att: **Searching for options** Att: **Formulating and implementing plan** Att: **Assessing the plan' s effectiveness** Conseq: **Physical activity**	information, evaluating the information and formulating a plan to manage PA would predict mothers' lifestyle PA, measured using accelerometers. Self-regulation activity of receiving information was the first predictor, followed by evaluating the information and then formulating a plan. Model was not significant at any step - including evaluating the information enabled the model to account for 27% of the variance in mothers' lifestyle PA, while the addition of SRQ formulating a plan increased the accounted for variance to 30%
Ginis & Bray (2010)	Quantitative; single-blind RCT to examine the effects of self-regulatory depletion on aerobic exercise planning and behavior	Baumeister's limited strength model of self-regulation – self-regulatory capacity is finite and can be depleted	Adults ages of 18 and 30 with no orthopedic, cardiac or respiratory limitations that would preclude exercise	Ant: **Self-regulatory strength** Conseq: **Exercise intensity**	Participants in the self-regulatory depletion condition reported a larger decrease in the planned intensity of their exercise bout from pre- to post-manipulation than

Table 1

Review of Self-Regulation Antecedents, Attributes, and Consequences

Author, Date	Study Focus, Method	Theoretical Basis	Study Format & Sample	Antecedents (Ant)/Attributes (Att)/Consequences (Conseq)	Conclusions
	2-group design with depletion and non-depletion (control) Hypothesized that individuals exposed to self- regulatory depletion manipulation would plan exercise and actually exercise at lower levels of intensity compared with people who were not depleted				participants in the control condition. After performing a depleting cognitive task, participants decreased the amount of work they performed during an exercise bout and reduced the intensity at which they planned to exercise later in the experimental session to a greater extent than participants in a control condition
Hofmann et al. (2015)	Quantitative; cross-sectional, experience sampling method Investigating if higher relationship satisfaction promotes a perspective that facilitates self-regulation, goal progress, and performance	States "In our model" (p. 435) but does not describe using a particular self-regulation theory. Describes self-regulatory processes "refers to psychological and behavioral processes that are oriented toward goal pursuit."	115 heterosexual couples (total N= 230) sampled at six random moments through each day for 1 week (42 text signals per partner in total). Each text a link to a brief survey that assessed relationship satisfaction and the relevant self-regulatory processes regarding the goal the participant was actively pursuing at that moment	Ant: **Perceived control** - extent to which the goal-pursuer feels in control of his or her goal performance (have control over actions and live in a structured world were actions have predictable outcomes) Att: **Goal focus**, extent to which the goal-pursuer's current thinking and behavior are oriented toward the target goal versus other distracting or competing goals Att: **Perceived Partner Support**: extent to which individuals perceive that their relationship partners facilitate their goal pursuit Att: **Positive Affect:** extent to which the goal pursuer experiences positive affect while pursuing the goal	Perceived control, goal focus, perceived partner support, and positive affect contribute to self-regulatory success through separable, independent mechanisms (as revealed through tests for significance of each indirect pathway)

Table 1

Review of Self-Regulation Antecedents, Attributes, and Consequences

Author, Date	Study Focus, Method	Theoretical Basis	Study Format & Sample	Antecedents (Ant)/Attributes (Att)/Consequences (Conseq)	Conclusions
Kalichman et al. (2011)	Quantitative; 2-group RCT; an initial test of an adherence intervention designed to reach patients by cell phone and sustain adherence between routine care visits	"self-regulation models" referred to in intervention description but no exact theoretical basis described; No definition of self-regulation provided	40 men and women receiving HIV antiretroviral therapy and less than 95% adherent to medication regimen Intervention delivered in a single office session followed by four biweekly cell phone counseling sessions medication adherence measured using data from phone-based, unannounced pill counts to provide feedback-guided adherence strategies	Ant: **Risk awareness** and **outcome expectancy, pre-action self-efficacy**: information on how HIV impacts the immune system, how antiretroviral medications slow the progression of HIV disease Att: **Action and coping planning**: personalized adherence plan with assistance of health counselor. Participants identify barriers to taking medications, also discussed antiretroviral medications, identifying the medications and creating a profile of times and dosing; integrating medications into daily routines. Att: Follow-up calls from counselor biweekly for four sessions: check in to see how participant doing. Pill count to determine adherence with **immediate corrective feedback**. **Discuss challenges**, **decisions made**, **plans to maintain adherence** or achieve adherence Conq: **Medication adherence** (measured by unnanounced pills counts) Conq: **Medication adherence self-efficacy** (measured by self-efficacy survey asking about pill adherence in a number of different situations)	Results showed that the self-regulation counseling delivered by cell phone demonstrated significant improvements in adherence compared to the control condition; adherence improved from 87% of pills taken at baseline to 94% adherence 4 months after baseline, $p < 0.01$. The observed effect sizes ranged from moderate ($d = 0.45$) to large ($d = 0.80$). Gains in adherence were paralleled with increased self-efficacy ($p < 0.05$) and use of behavioral strategies for medication adherence ($p < 0.05$).

Table 1

Review of Self-Regulation Antecedents, Attributes, and Consequences

Author, Date	Study Focus, Method	Theoretical Basis	Study Format & Sample	Antecedents (Ant)/Attributes (Att)/Consequences (Conseq)	Conclusions
Koring et al. (2013)	Quantitative: cross-sectional, longitudinal physical activity survey: investigating whether preparatory action is being performed, and, if so, whether this makes a difference for the target behaviors (physical activity in the present study)	Discusses outcome expectancy and perceived self-efficacy from social cognitive theory; preparatory planning cited from previous research on physical activity	Longitudinal physical activity survey conducted with 143 university students offered a free pedometer. Collecting this free gift served as indicator of preparatory behavior. Outcome expectancies and self-efficacy beliefs were specified as predictors of this behavior. Two weeks later, physical activity differences between the groups were determined	Ant: **Outcome Expectancy** Ant: **Perceived Self-Efficacy** Att: **Preparatory Planning** Conseq: **Physical activity** measured with International Physical Activity Questionnaire (reported frequency of leisure time physical activity that they performed during the last week)	Collecting free pedometer served as indicator of preparatory behavior. Outcome expectancies and self-efficacy beliefs were specified as predictors of this behavior Collecting pedometer was associated with higher levels of physical activity at follow-up. Outcome expectancies failed to predict the pedometer collection, but self-efficacy did
Kuo et al. (2013)	Quantitative; two-group, pretest–post-test experimental design. physiological and psychological efficacy of a self-regulation protocol in lowering acute exacerbation symptoms in patients with chronic obstructive pulmonary disease.	"In this study, we used self-regulation theory" which includes three elements of self-monitoring, self-judgment and self-reaction to design the intervention protocol	64 participants randomly assigned either to an intervention (n = 33) or comparison (n = 31) group. Both groups assessed on four separate occasions, pretest, post-test 1 (5th week), post-test 2 (9th week) and post-test 3 (13th week) The intervention group received a four-week self-regulation protocol. The comparison group received self-regulation guidebook only	Att: **self-monitoring,** participants recorded the level of dyspnea, pulmonary function, and frequency of contact with symptom exacerbation factors. Att: **self-judgment**; explained how to judge individual exacerbation factors. Att: **self-reaction**; explained how to keep airways warm, quit smoking, avoid contact with indoor/outdoor air pollutants, control exercise and daily behaviors, do pulmonary rehabilitation exercises, correctly use the inhaler and treat acute exacerbation	On the 5th, 9th and 13th weeks after the self-regulation protocol intervention, found significantly better scores in the four symptom and pulmonary function scales in the intervention group compared to those in the comparison group. On 9th and 13th weeks, significantly greater peak expiratory flow in the intervention group. The intervention group showed lower rate of unscheduled

Table 1

Review of Self-Regulation Antecedents, Attributes, and Consequences

Author, Date	Study Focus, Method	Theoretical Basis	Study Format & Sample	Antecedents (Ant)/Attributes (Att)/Consequences (Conseq)	Conclusions
				Conseq: **improved peak expiratory flow, decreased unscheduled physician visits, improved symptom control**	physician visits because of acute exacerbation than the comparison group
Lange et al. (2013)	Quantitative: RCT; purpose was to examine whether 1hr intervention would help increase fruit consumption and to study the role of self-regulatory mechanisms in the behavior change process	Intervention described as "theory guided" but no specific mention of exact self-regulation theory utilized	1,154 participants randomized to intervention or control group. Intervention group received volitional treatment that lasted on average 45 min. The control group received a standard care intervention	Ant: **Motivation** (participant interest in increasing fruit consumption assessed on enrollment) Att: **Planning** Att: **Action Control - measured using 3 survey items assessing:** • **Self-monitoring** • **Awareness of Standards** • **Self-Regulatory Effort** Conseq: **Fruit intake**	Intervention group consumed more fruit than participants in control condition. Dietary planning and action control play a role in the mechanisms that facilitate fruit intake
Luszczynska & Schwarzer (2003)	Quantitative: risk perceptions, outcome expectancies, self-efficacy, intention to perform Breast Self Examination (BSE), planning, and reported examination behaviors were examined at two points in time	HAPA model used to design measurements related to health self-regulation	720 women. College or university students of psychology, nursing, education, business administration, and medicine, from eight universities and colleges in central and northern Poland.	Ant: **Risk perception** Ant: **Outcome expectancies** Ant: **Intention to perform health behavior (BSE)** Ant: **Pre-action self-efficacy** Ant: **Previous BSE Behavior** Att: **Planning** Att: **Maintenance Self-Efficacy** Att: **Recovery Self-Efficacy** Conq: **BSE Behavior**	Self-efficacy emerged as the best predictor of intention and planning Planning was best predictor of BSE behaviors, followed by self-efficacy
Marques et al. (2015)	Quantitative: 2-group, 12-week RCT aimed at assessing effects of self-regulation-based physical	"According to self-regulation theory" (p. 188) - article cited that reviews a compendium of self-regulation	91 adult patients meeting the CDC criteria for idiopathic chronic fatigue 4-STEPS program	Ant: **Self-efficacy** Ant: **Motivation** Ant: **Control over competing goals** Att: **Goal-setting** Att: **Action Planning**	At post-treatment, significant difference for subjective experience of fatigue (4.73 points; g=0.51) in favor of the intervention group.

Table 1

Review of Self-Regulation Antecedents, Attributes, and Consequences

Author, Date	Study Focus, Method	Theoretical Basis	Study Format & Sample	Antecedents (Ant)/Attributes (Att)/Consequences (Conseq)	Conclusions
	activity program for patients with unexplained chronic fatigue	theories so not clear as to the exact theoretical source for this intervention	consisted of motivational interviewing and self-regulation skills training. All patients assessed at baseline and post-treatment (12 weeks) for fatigue severity, physical activity levels, personal activity goal progress, health-related quality of life, somatic distress and psychological distress	Att: **Self-Monitoring** Att: **Coping efficacy** Att: **Planning** Att: **Feedback** Att: **Attention** Att: **Emotional Regulation** Att: **Relapse Prevention** Att: **Coping Efficacy and Planning** Att: **Goal Reformulation** Conq: **Physical activity**	significant effect of the 4-STEPS on fatigue severity, leisure time physical activity, personal activity goal progress and health-related quality of life.
McKee et al. (2013)	Qualitative: investigate differences in contributing factors involved in weight maintenance success and failure. Thematic analysis of semi-structure interviews	No theory identified	19 participants, nine of whom had lost 10% of their body weight and maintained this list for a minimum of 12 months (Maintainers); other nine individuals met the above criteria for weight loss but had subsequently regained their weight (Regainers)	Att: **Goal setting** (long-term, realistic) Att: **Routines** (consistent) Att: **Self-Monitoring** Att: **Avoiding Deprivation** Att: **Effective Coping Skills** Conseq: **Weight loss maintenance**	Two main themes highlighted the differences between the two groups, these were: goal regulation and self-control. Successful weight maintenance was related to the following subthemes: long-term, realistic goal setting, consistent use of routines and self-monitoring, avoiding deprivation and effective coping skills. Unsuccessful maintenance was related to short-term unrealistic goal setting, inconsistent routines and self-monitoring, experiencing deprivation and poor coping skills

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McKee & Ntoumanis (2014)	Quantitative: 2-group non-randomized design; aim to investigate whether a self-regulatory skills intervention can improve weight loss-related outcomes	References to a number of health behavior change articles but no theoretical framework or model for intervention development identified	self-regulation training group (intervention) was trained to use six self-regulatory skills. Advice group (control) received dietary and physical activity advice for weight loss. Physical, self-regulatory, and psychological measures were taken at baseline, end of intervention (week 8) and at follow-up (week 12).	Att: **Delayed gratification** Att: **Self-monitoring** Att: **Thought control** Att: **Goal-setting** Att: **Mindfulness** (focusing on body signals as well as sensory experiences, thoughts, and emotions Att: **Coping skills** (e.g., response to relapse) Conseq: **Weight loss**	Weight, waist circumference, body fat and body mass index (BMI) were significantly reduced at follow-up for both groups Significant increases in all six self-regulatory skills and the psychological measures of self-efficacy, self-regulatory success, and physical self-worth for both groups
Milyavskaya et al. (2015)	Quantitative: 3 studies investigating the effects of 'want-to' and 'have-to' motivation on both the impulsive (desires and obstacles) and reflective (effortful self-control) systems, including their effects on goal attainment	Theories cited include self-determination theory (Deci & Ryan, 2000)	Study 1: 96 Canadian undergraduates administered Regulation of Eating Behavior questionnaire to assess motivation for eating healthy Study 2: 159 Canadian undergraduates assessed for want-to and have-to motivation for healthy eating and frequency of obstacles to healthy eating encountered Study 3: 344 undergraduates set three goals at start of semester and completed	Ant: **Goal-setting** Ant: **Want-to Motivation** Ant: **Have-to Motivation**	Across 3 studies, results show that want-to motivation result in decreased impulsive attraction to goal-disruptive temptations and is related to encountering fewer obstacles in the process of goal pursuit. Want-to goals are more likely to be attained. Have-to motivation was unrelated to people's automatic reactions to temptation cues but related to greater subjective perceptions of obstacles

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			measures related to perceived effort, obstacles, motivation, goals progress throughout the semester. Want-to vs have-to motivation assessed related to student goals.		and tempting desires
Plaete et al. (2015)	eHealth intervention, MyPlan 1.0, based on self-regulation theory. Aimed at increasing fruit and vegetable intake and physical activity	Health Action Process Approach	No sample: Intervention development described	Ant: **Motivation** influenced by risk awareness, outcome expectancy, and pre-action self-efficacy. **Motivation includes goal selection** Att: **Monitoring target behavior levels** Att: **Evaluating progress to goal** Att: **Action planning**, **coping planning** Att: **Action – pursue goal** Att: **Maintenance self-efficacy** Att: **Social support** Conseq: **Fruit and vegetable consumption; physical activity**	No conclusions; intervention not tested
Scholz et al. (2009)	Quantitative; health-behavior change focusing on associations between changes in predictors (action control and action planning) and change in behavior (low-fat diet, smoking)	Health Action Process Approach	Two online-studies targeting different behaviors (low-fat diet, smoking), different samples (Study 1: N = 469; Study 2: N = 441) and different time spans (Study 1: 3 months, Study 2: 4 weeks)	Ant: **intention** is necessary but not sufficient for behavior change. (intention influenced by **risk awareness, outcome expectancy, self-efficacy**) Att: **Action planning**: forming concrete plans about when, where, and how to implement behavior. Att: **Self-monitoring** refers to the process of monitoring one's own	Change in action planning and especially action control was of significant importance for behavior change across smoking and dietary fat intake (of greater importance than intentions alone) Change in action control displayed the strongest

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	Quantitative: longitudinal, correlational			behavior to evaluate whether further regulatory effort is necessary to reduce discrepancies between one's actions and intentions Att: **Awareness of own standards** individual is constantly aware of their intentions in terms of behavior change Att: if discrepancies between one's own actions and intentions are perceived, **self-regulatory effort** must be invested by applying discrepancy-reducing means Conseq: **Low-fat diet; smoking cessation**	direct effect on change in behavior
Schuz et al. (2013)	Quantitative: role of health motives in health behavior self-regulation (physical activity), particularly in the mediation of intention effects on behavior via planning	Health Action Process Approach and Implementation Intentions theory	309 community-dwelling adults with multiple illnesses aged 65 and older Health motives were assessed by contrasting health ratings with all other domains on the Personal Life Investment Schedule	Att: **Health motives** (measured by Personal Life Investment Schedule) Att: **Intentions** Att: **Planning (coping and action)** Conseq: **Physical activity**	Health motives moderated degree to which intentions predicted behavior via planning (intention x health motives $\beta = .18$, $p < .05$) Intentions better translated into planning and behavior if health motives present
van Osch et al. (2010)	Quantitative; prospective, longitudinal; Investigated impact of two types of self-regulatory planning on health promoting behavior	Cites previous research to support consideration of two separate forms of planning – preparatory and implementation (Bagozzi, 1992; Abraham, 1999; van Osch et al.,	434 respondents completed baseline, 4 weeks, and 8 weeks questionnaires regarding fruit consumption behaviors	Ant: **Self-Efficacy for fruit consumption** Ant: **Intention** Att: **Preparatory planning** (planning of strategies and preparatory actions towards a goal behavior) Att: **Implementation planning (**planning of when, where, and how	Preparatory planning (ß = 0.21; $p < .001$) and implementation planning (ß = 0.13; $p < ,01$) were significant predictors of fruit intake, above the influence of motivational factors. Implementation planning did not contribute to the

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		2008)		to perform a goal behavior) Conq: **Fruit consumption**	prediction of fruit consumption over and above the influence of preparatory planning when tested simultaneously

Identify All Uses of Self-Regulation

For an initial exploration of self-regulation uses, prior to conducting the literature review outlined above, various dictionaries were consulted, as recommended by Walker and Avant (2011). The Oxford English Dictionary (2017) defines self-regulation as "the fact that, something such as an organization, controls itself without intervention from external bodies," and Collins Dictionary (2017) defines it as "controlling of a process or activity by the people or organizations that are involved in it rather than by an outside organization such as the government." Both definitions consider the element of self-control to be integral to self-regulation. Problematically, when it comes to defining how self-regulation is used in the literature, the term has been use interchangeably for other concepts. Butson et al. (2014) examine the role of parental self-regulation in family physical activity using a cross-sectional survey administered to mothers and fathers. The article presents a self-regulation questionnaire as as a measure of 'participants' behavioral self-control,' leading the reader to conclude that self-regulation is measured by self-control. Kalichman et al. (2011) conduct a study of behavioral self-regulation counseling for HIV treatment adherence delivered via cell phone and refer to their intervention as encompassing 'self-management/self-regulation,' without delineating how these two terms relate or if they are intended to be interpreted as synonymous. However, there have been efforts in the literature to keep self-regulation distinct from other related concepts. Carver and Scheier (1998) specify self-control as the overriding of tendencies for certain actions in order to reach a desired goal. When looking across articles included in this review, a definition of self-regulation emerges that is more process-oriented than controlling tendencies or avoiding temptations, as self-control implies. Self-control is relevant to self-regulation, and will be considered in turn.

Self-regulation is described in much of health behavior literature as a self-directed or volitional process where individuals make choices about actions they will take to meet a particular goal (De Ridder & De Wit, 2006). Including "process" and "goals" as salient components of self-regulation, it is necessary to examine these concepts further. Goals can vary in terms of their longevity, level of abstraction, congruence, and polarity (moving towards an incentive compared to avoiding a threat) (De Ridder & De Wit, 2006). For example, consider how complex goals become when you envision a common situation – a single person with the two goals of drinking more dairy to increase calcium and becoming healthy. If the goal of becoming healthy can have its abstraction reduced and converted to a more concrete goal of becoming healthy by losing 10 pounds, the individual may be faced with the obstacle of goal incongruence because of competing interests – oftentimes dairy is high in calories so increasing dairy intake will lead to increased weight gain, despite the fact that the dairy may improve bone structure. This scenario illustrates the familiar quandary where one goal threatens another.

Though goals cannot always be made congruent and individuals are faced with competing choices, reducing discrepancies is a reoccurring characteristic of self-regulation in the literature. Individuals transitioning from an unhealthy to a healthy state using the self-regulation process involves minimizing or eliminating discrepancies that exist between our perceived standards, values, beliefs, and our current state of being (De Ridder & De Wit, 2006). This process of discrepancy adjustment takes the form of a negative feedback loop and includes perception of present state, compared to a desired state (goal). If a discrepancy is recognized, subsequent activities are aimed at bringing present and desired states in alignment. The variability in how humans go about this process is staggering – consider the variety of behavior changes enacted in the service of "becoming healthy." Though the idea of a discrepancy-reducing loop is appealing (e.g., making my behaviors match my goals), it is the variability in

how humans engage in the self-regulation process that contributes to the complex and oftentimes incongruent results we see in behavior change research (De Ridder & De Wit, 2006).

Though the majority of the articles reviewed for this concept analysis embraced self-regulation as a process, there are researchers who investigate the concept as a resource. Ginis & Bray (2010) applied Baumeister's limited strength model of self-regulation to understanding exercise effort, planning, and adherence. According to Baumeister's limited strength model of self-regulation, self-regulatory capacity is finite and can be depleted, like a resource (Baumeister, Bratslavsky, Muraven, & Tice, 1998). Ginis and Bray's single-blind, randomized control trial examines the impact of self-regulatory depletion on aerobic exercise planning and behavior. They hypothesized that individuals exposed to a self- regulatory depletion manipulation would plan exercise and actually exercise at lower levels of intensity compared with people who were not depleted. Of the 18 articles reviewed, this is the only example of theory-guided self-regulation research that included the resource perspective of self-regulation. Description of self-regulation as a process, or steps in a process, is the far more common characterization of the concept.

In support of self-regulation as a process as opposed to a resource or strength, a number of studies reviewed suggested that self-regulation is a process that people engage in, and, that self-regulation activities can be taught. Lange et al. (2013) used a randomized control trial to examine whether a 1-hour intervention would help increase fruit consumption in motivated individuals and to study the role of self-regulatory mechanisms in the behavior change process, with a particular focus on dietary planning and self-monitoring. Participants receiving the interventions not only consumed more fruit than the control but engaged in dietary planning and self-monitoring more frequently. Intervention studies that teach self-regulation vary in their delivery of instruction, including use of a "health intervener" providing 1:1 training on use of

steps in the self-regulation process (Kuo et al., 2013), computer-based self-regulation modules including behavior change scenarios (Annesi, 2011), and static content describing self-regulation steps in a workbook format (Marques et al., 2015). Intervention studies were included in this concept analysis to consider the issue of whether or not self-regulation is comprised of activities that can be learned or if it is more accurately regarded as a finite strength or resource. Studies of self-regulation interventions reviewed typically included multiple self-regulation activities taught to participants without a clear presentation of whether or not these activities could occur simultaneously, or if the process could move in a back and forth manner. This leaves the unanswered question of whether or not self-regulation is a non-linear process that may involve individuals vacillating back and forth between activities and/or engaging in more than one activity at the same time.

Regarding the potential chronology of each self-regulation activity, reason dictates that if self-regulation is the process of pursuing a goal, setting a goal has to be one of the earliest activities an individual undertakes. Planning for achieving the goal and implementing those plans follows goal-setting. Most studies of self-regulation also include a self-monitoring step, and fewer include self-evaluation. However, as will be examined in the attributes section of this article, there are a number of additional activities, combinations, and permutations to consider. Though there are some reasonable assumptions about the ordering of self-regulation activities, as discussed above, the literature reveals that there no evidence supporting a single, linear, self-regulation process.

Studies of self-regulation reviewed reveal the diversity of attributes that are considered by health behavior change researchers as falling under the umbrella of 'self-regulation.' Before moving into a consideration of these attributes, a summary of the defining characteristics of self-regulation is included below:

Self-regulation characteristics include:

- A self-directed process, meaning activities undertaken to meet a particular end, typically a goal which may be superordinate ("to be more healthy") and contain sub-goals (e.g., lose 10 pounds, increase weekly physical activity, reduce cigarette smoking)
- An individual's ability to engage in self-regulation can be developed using multiple modalities (e.g., self-taught, learned in a group setting, role modeled)
- Process activities are not necessarily linear in nature; they may occur simultaneously or be repeated throughout the pursuit of a goal. The notable exception being the activity of setting the goal, which has to be completed before an individual can begin pursuing that goal.

Identify Defining Attributes of Self-Regulation

Walker and Avant (2011) state that attributes appear in the literature when describing the concept and are used to differentiate the concept from other concepts. Attributes are characteristics most frequently associated with the concept of self-regulation in the context of health behavior change and provide the broadest insight into the individual's experiences (Walker & Avant, 2011). Defining attributes facilitates a clearer understanding of the concept. At the center of Figure 3, the key attributes derived from this concept analysis are listed: goal-setting, planning, self-monitoring, performance assessment, and self-efficacy. Each of these attributes will be discussed in relation to the literature.

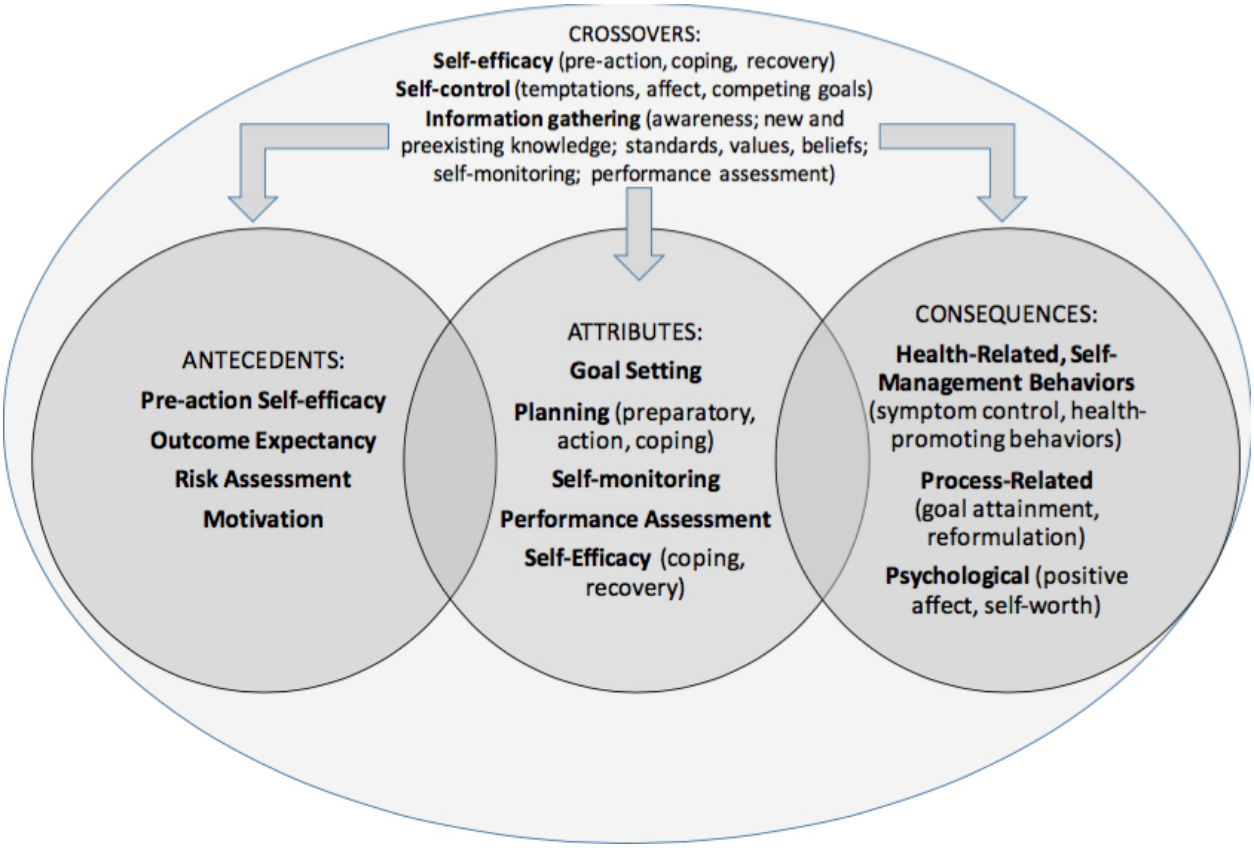

Figure 3. Crossovers, attributes, antecedents, and consequences of self-regulation

As it pertains to health behavior change, before engaging in the process of goal pursuit, self-regulation literature supports the primacy of setting a goal. Of the 18 articles reviewed, all consistently presented goal formulation, be it for increased physical activity, smoking cessation, changes in diet or goals specific to a particular disease, such as COPD or asthma. Goals can be described as thoughts about, or mental representations of, desired outcomes or states. As delineated above in describing the characteristics of self-regulation, goals are more likely to be pursued and achieved if they are self-selected and realistic from the individual's perspective (Baptist, Ross, Yang, Song, & Clark, 2013; McKee, Ntoumanis & Smith, 2013). Goals can be classified in a number of ways, but according to the studies reviewed there is a clear divergence in the type of selection that occurs. This distinction noted in the literature reviewed is consistent with Deci and Ryan's (1985) Self-Determination Theory (SDT) which postulates that goal

selection can be autonomous or controlled. An autonomous goal originates with the self, meaning it is developed and selected by the individual, whereas the controlled goal is externally imposed upon them by social influence (such as healthcare providers) or other outside forces. Empirical evidence from the SDT perspective reveals that participants in a weight loss program whose motivation for weight loss was relatively more autonomous attended the program more regularly, lost more weight during the program, and maintained their weight loss at follow-up (Williams, Grow, Freedman, Ryan, & Deci, 1996). Another study addressing adherence to long-term medication prescriptions in adult outpatients with various diagnoses confirmed that patients' autonomous motivation was related to medication adherence (Williams, Rodin, Ryan, Grolnick, & Deci, 1998).

Higgins (1996) found that a goal that fits with personal values, interests, and other goals should be chronic, and thus accessible much of the time. Specifically, chronic accessibility stems from repeated use or activation of a construct. If a given goal is closely related to a person's values, interests, and other goals, it should be easily activated whenever these values, interests or other goals become salient, and consequentially be active much of the time. Active goals then influence automatic processes, including attention, evaluation, and behavior, both as these active goals relate to goal pursuit and to competing temptations. For example, research has shown that when a goal is activated, people implicitly evaluate goal-related stimuli more positively (Ferguson & Bargh, 2004). Other research has found that active goals are "shielded" from competing goals, such that stimuli related to other goals (e.g., the goal of instant pleasure) become less salient (Shah, Friedman, & Kruglanski, 2002).

Closely behind goal selection in terms of frequency mentioned in the literature are the self-regulation steps of planning and self-monitoring. Self-monitoring refers to the process of monitoring one's own behavior in order to evaluate whether further regulatory effort is necessary

to reduce possible discrepancies between one's actions and goals. For example, a person's goal is to lose 10 pounds in 3 weeks, but if she tracks her behavior and realizes that she is continually indulging in high fat foods (self-monitoring), she will need to make adjustments in her eating habits to better alignment them with her goal. Self-monitoring is interesting in that some articles reviewed include it as part of a broader theorized self-regulation component of action control, which also includes self-regulatory effort and awareness of standards (Lange et al., 2013; Scholz, Nagy, Gohner, Luszczynska, & Kliegel, 2009). Kuo et al. (2013) provide an example of self-monitoring as part of an intervention with patients who have chronic obstructive pulmonary disease (COPD). Participants use "self-monitoring record sheets" where they track COPD symptoms, circumstances preceding exacerbations, level of symptom distress, and record peak expiratory flow measures (i.e., measure of lung function).

Planning appears in the literature in a variety of forms. Planning is generally understood as a means to simulate behavior mentally and prospectively, in order to be prepared for situations in which the behavior should be performed (Morris & Ward, 2005). In Scholz et al. (2009) action planning is defined as forming concrete plans about when, where, and how to implement the intended behavior. In the self-regulation process, the literature is consistent in presenting action planning as critical for behavior change, though this step is frequently referred to simply as 'planning.' Having a plan is more effective than having intentions alone when it comes to the likelihood and speed of behavior performance, partly because behavior may be elicited almost automatically when the relevant situational cues are encountered; people do not forget their intentions easily when specified in a when, where, and how manner. However, identifying the when, where, and how of a behavior is not the only type of planning described. Plaete and colleagues conducted a study including an eHealth self-regulation intervention for increasing fruit consumption and physical activity based on the Health Action Process Approach (Plaete,

Bourdeaudhuij, Verloigne, Oenema, & Crombez, 2015). This theory-guided study not only included action planning but also coping planning, which is a different way of planning focused on the anticipation of barriers and the generation of alternative plans to overcome them (Scholz, Sniehotta, Burkert, & Schwarzer, 2007). In coping planning, people imagine scenarios that hinder them from performing their intended behavior, and they develop one or more plans to cope with this challenge. For example, if Sam plans to run on Sunday but the weather does not permit it, he plans to run on the treadmill in my basement instead. Whereas action planning is a prerequisite for initiating new behaviors, coping planning is a strategy that becomes more relevant after the intended behavior is initiated. Eight of the 18 studies reviewed included either action planning (also referred to as implementation planning or simply planning) or coping planning (Luszczynska & Schwarzer, 2003; Scholz et al., 2009; Plaete et al., 2015; Marques et al., 2015; Lange et al., 2013; Ginis & Bray, 2010; Kalichman et al., 2011; Schuz, Wurm, Warner, Wolff, & Schwarzer, 2013).

Two studies contributed an additional form of planning to this analysis, called preparatory planning (Koring et al., 2013; Osch et al., 2010). Osch et al. (2010) investigated the impact of two types of planning on health promoting behaviors, one of them being preparatory planning and the other implementation planning. In their study, structural equation modeling was conducted on questionnaire data from approximately 430 participants related to their intentions and plans to increase fruit consumption. Both types of planning were found to be significant predictors of fruit consumption, over and above the influence of motivational factors. Comparison of differences in explained variance indicated that the contribution of preparatory planning was larger than that of implementation planning. Preparatory planning implies the planning of specific preparatory or instrumental acts in the service of ultimate goal achievement. Respondents were asked to what extent they planned to perform several actions or preparatory

behaviors in order to reach the target behavior of increased fruit consumption. The item stem asked in the questionnaires was: 'Have you made a plan to. . . ' followed by the items: (a) 'buy fruit', (b) 'eat fruit at a fixed time of day' (c) 'put a fruit basket on the table', (d) 'take fruit along with you when you go somewhere,' and (e) 'replace unhealthy snacks by fruit.' Preparatory behaviors are also relevant in other health behavior domains, for example in physical activity, where several preparatory behaviors might be conceivable, such as registration in a fitness club, purchasing sports clothes, or simply preparing one's sports bag. Preparatory behaviors might facilitate the adoption of a health behavior, as barriers are minimized and cues to action are encountered more frequently. Among others, purchasing a pedometer, for example, might be regarded as a preparatory step that could lead to higher levels of physical activity.

Beyond the self-regulation activities of goal-setting and planning, the articles reviewed considered how individuals eventually evaluate progress that has been made towards a self-directed goal. However, for the articles reviewed, feedback or evaluation was infrequently mentioned as an attribute of self-regulation. Two of the 18 articles discussed feedback, and only in vague terms as an element of a self-regulation interventions (Plaete et al., 2015; Marques et al., 2015). In Marques et al. (2015), researchers provide descriptions of a self-regulation intervention related to physical activity, and feedback is mentioned as a self-regulation skill, but is never further explained. Ford and Nichols (1987) discuss that active goal pursuit involves feedback that includes monitoring and evaluation of progress towards a goal on the basis of knowledge of behavioral results. Despite the fact that Ford and Nichols wrote on self-regulation almost three decades ago, feedback as an attribute in self-regulation literature is not clearly defined or described, nor is is readily distinguishable from other related terms such as evaluation or assessment.

It was necessary to look outside of the 18 articles in this review to attempt clarification of

feedback, but the topic becomes even more convoluted when related terms are added to the discussion. The terms "feedback," "evaluation," and "assessment" were searched in CINAHL, ERIC, PsycINFO, and Medline databases. The most common context where these terms are applied is in the field of education. An article by Shehmar and Khan (2010) attempts to formulate definitions to help distinguish these terms from one another. Shehmar and Khan (2010) divided assessment into two types: summative assessment containing decisions (pass/fail) while formative assessment is a comparison against set standards which encourages educational development and feeds into summative assessment. In the context of education, evaluation is a judgment about a training program, trainer, or trainee designed to lead to continuous improvement (Shehmar & Khan, 2010). Feedback is judgment about a trainee's learning achievements and needs, designed to lead to continuous improvement (Shehmar & Khan, 2010). As is evident from Shemar and Khan's efforts to distinguish these closely related concepts from one another, the differences are not readily perceptible and overlap still exists.

Returning to the concept of self-regulation and taking definitions of feedback, evaluation, and assessment into consideration, we add to our list of self-regulation attributes performance assessment and define it as judgments made in light of set standards (e.g., stated goal, a specific plan, personal values). These judgments can include appraisals of success and failure of previous and current goal pursuits (or plans) and may encourage ongoing improvement. As considered above, although evaluative terms such as 'feedback' received limited description in current self-regulation studies, assessments are arguably an ever-present aspect of goal pursuit and form a basis from which individuals continuously make decisions about goals, plans, and actions. Therefore, although there is a struggle with including an attribute of self-regulation that is inadequately discussed in contemporary self-regulation research, perhaps the literature has not kept pace with how individuals actually pursue health behavior goals.

Crossovers

'Crossovers' is a term used to describe components of self-regulation that the author considers to transcend antecedents, attributes, or consequences. The uppermost cell of Figure 3 lists the crossovers identified in this concept analysis, with three arrows branching from this cell and extending to antecedents, attributes, and consequences, meant to signify that crossovers, as the name implies, can appear in multiple cells. Crossovers include self-efficacy, self-control, and information gathering.

In the articles reviewed, self-efficacy is most frequently presented as an antecedent to self-regulation. In other words, it is discussed as preceding and influencing goal selection (if a person has no confidence in his ability to run 3 miles, he is unlikely to set this behavior change goal) (Marques et al., 2015). However, after reviewing self-regulation literature, self-efficacy does not only precede goal-setting, but different versions of self-efficacy are also threaded throughout the individual's behavior change experiences. Therefore, self-efficacy can be classified in different ways depending on where is falls in the self-regulation process. Pre-action self-efficacy refers to a person's beliefs concerning his or her ability to begin actions and gather the resources needed to overcome challenges involved in behavior initiation, such as scheduling daily routines to allow regular insulin injections for a diabetic patient (Luszczynska & Schwarzer, 2003). Examples of pre-action self-efficacy statements include: "I am certain I can quit smoking in the next 3 months" or "I am certain that when I quit smoking that I can do it for good." Maintenance self-efficacy is confidence that an individual will be able to sustain a behavior that they have initiated (Plaete et al., 2015). Maintenance self-efficacy is also termed coping self-efficacy since it focuses on the inevitable obstacles to continuing behavior that arise in life. For example, "I am certain I can refrain from smoking even if I feel stressed out or anxious." Lastly, recovery self-efficacy is confidence in being able to resume a behavior even

after it has been disrupted (Luszczynska & Schwarzer, 2003; Plaete et al., 2015). The emphasis is on gaining confidence after a relapse. An example of recovery self-efficacy assessment would be: "Imagine that you have resumed smoking for whatever reasoning. How confident are you that you could quit again if you smoked one cigarette?"

Information gathering provides another example of a crossover dimension of self-regulation. Information gathering refers to accessing and reflecting on information about a problem and the possible options for addressing that problem. Although the term 'information gathering' is not explicitly cited in the self-regulation literature reviewed, it consistently accompanies discussions of engaging in self-regulation. In Kalichman et al.'s (2011) study of self-regulation counseling and its impact on HIV medication adherence, part of the self-regulation counseling was dedicated to imparting information about what HIV is, how it impacts the immune system, how antiretroviral therapy works. Although researchers labeled this information as being part of risk awareness and outcome expectancy, the wider category being described is that of imparting information about the disease and it treatments. Using the broader term of 'information gathering' is also more consistent with the fact that not all information collected as part of self-regulation is focused on risk awareness and outcome expectancy. Therefore, the term 'information gathering' is inclusive enough to encompass the types of information that individuals amass as they are making health behavior change decisions, or even trying to decide what health goal they should set. Information gathering could include accessing preexisting or new knowledge about a health condition of behavior change; self-feedback or feedback provided by members of a person's social sphere; or information that emanates from previous experiences with self-regulation successes and failures.

A third crossover component identified in the literature was self-control, which refers to the effort that a person has to expend in order to control impulses and temptations in the service

of a desired outcome (Milyavskaya, Inzlicht, Hope, & Koestner, 2015). In the case of self-regulation, this desired outcome is likely the achievement of a particular goal. To illustrate the point, if a person intends to increase fruit and vegetable consumption throughout the day, she might have to exercise varying levels of self-control in order to resist the temptation and immediate gratification of eating fast food instead. Self-control could be expended to curb impulses, affects, temptations to engage in undesirable behaviors, or spending time and energy pursuing a competing goal (e.g. "I should work on my term paper, but I also want to use that time to visit a sick relative"). When considering the innumerable opportunities for an individual to be distracted from their intended health behavior goal, self-control is a vital attribute of self-regulation as an individual is making plans, monitoring behaviors, and implementing actions. However, before a person can even engage in self-regulation, she or he must be capable of engaging in self-control to resist the internal and external stimuli that could dissuade her from ever setting a behavior change goal in the first place.

Identify Antecedents and Consequences

Walker and Avant (2011) propose that antecedents are precursors to a concept. The antecedents identified in this concept analysis and seen in Figure 3 include pre-action self-efficacy, outcome expectancy, risk assessment, and motivation.

One of the reoccurring antecedents to self-regulation appearing in the articles reviewed was motivation to change health behaviors. However, motivation itself has antecedents that were examined in the articles included in this concept analysis as well. A number of studies articulated precursors to individuals formulating the motivation to initiate behavior change. Risk awareness refers to assessment of absolute or relative health risk, addressing a specific disease or a broader illness category (Weinstein, 2003). Risk awareness is defined as the perceived personal vulnerability to a health threat (Weinstein, 2003). Perception of one's own risk is often

the starting point for forming health behavior change intentions (Weinstein, 2003). In Kalichman et al. (2011), researchers include a brief self-regulation counseling session with HIV positive participants, as part of risk awareness and outcome expectancy interventions participants were provided with information on how HIV impacts the immune system and how antiretroviral medications slow the progression of HIV disease. An example of how risk awareness can be measured includes assessment items such as: "compared to the average person of my age and sex, my chances of having a heart attack are..." Outcome expectancies also influence motivation and can be classified as positive or negative and cover a variety of domains including emotional, social, and physical outcomes. It is assumed that the higher the perceived advantages (i.e. positive outcome expectancies) of a health behavior change and the lower the perceived disadvantages (i.e. negative outcome expectancies), the more likely people are to build an intention to change their behavior. Example of outcome expectancies include "If I quite smoking, I anticipate seeing personal consequences that include: being more attractive to others (e.g., white teeth, better skin, no odor to clothing); I will feel better physically; I will have lower cholesterol." Self-efficacy is also a factor contributing to motivation and goal selection, as we considered in the preceding section where pre-action self-efficacy was discussed.

Walker and Avant (2011) state that consequences are the outcomes related to the concept. Consequences of self-regulation identified in the articles reviewed could be divided into three categories: health-related, self-management behaviors, process-related, and psychological consequences. Health-related, self-management behaviors associated with self-regulation were by far the most frequently mentioned. All 18 investigations examined a particular health behavior that participants were striving to implement, be it symptom control (Baptist et al., 2013), increased functioning (Kuo et al., 2013), reduced disease exacerbations (Kuo et al., 2013), disease management (Kalichman et al., 2011), adoption of health-promotion or disease-

prevention behaviors such as increased physical activity (Butson et al., 2014), breast self-examination for cancer screening (Luszcynska & Schwarzer, 2003), or increased fruit consumption (van Osch et al., 2010). It is important to note that adopting a new health behavior is different from changes made to a pre-existing behavior. For a new behavior, the main issue is its initiation, and therefore, planning is the primary focus. Pre-existing behaviors, in contrast, that become a target for modification first require an accurate monitoring of present action to understand the modifications that need to be made. Figure 3 reflects this assertion by including self-monitoring as a crossover component of self-regulation that may be applicable at multiple points in the process. For example, if Robert already believes that he walks a lot in his current job, and he sets the health behavior goal of walking 10,000 steps a day, he needs to determine his baseline – in other words, he must self-monitor and assess the current number of steps he achieves per day before he can make a plan to change his behavior to meet the goal of 10,000 steps per day.

Since self-regulation is the process of pursuing one's goals, another category of consequences mentioned sparingly in the literature emphasized aspects of the self-regulation process as potential consequences. McKee & Ntoumanis (2014) examined self-regulation in the context of resisting dietary temptations, and identified a consequence of practicing self-regulation to be increased use of self-regulation skills in the future. Goal attainment could be considered a process-related consequence of self-regulation, as achievement of one's health behavior change goal is the impetus for engaging in self-regulation in the first place. Other potential process-related consequences of self-regulation are that a person either decides to maintain the behavior (habit formation) or he adapts some aspect of the process (e.g., modifies a goal or retains the same goal but changes the plan for pursuing that goal) (Marques et al., 2015). Similarly, Plaete et al. (2015) identified goal reformulation as a possible consequence of self-

regulation. Psychological consequences of self-regulation are discussed by McKee and Ntoumanis (2014) as including increased self-efficacy and self-worth. Hofman, Finkel, and Fitzsimmons (2015) discuss positive affect as a consequence of self-regulation.

Important to consider is that although this concept analysis groups self-regulation consequences into three general clusters, this is by no means the definitive categorization. For example, when considering process-related and self-management behaviors as consequences, it is conceivable that a specific example could fall into both categories. For example, in Kalichman et al.'s (2011) study of HIV patients' adherence to antiretroviral therapy, although a self-management behavior achieved may be improved symptom control, this could also easily be classified as goal attainment (a process-related consequences of self-regulation). This example is mentioned to illustrate that although categories of consequences are included in this discussion in an effort to organize the literature reviewed, these are not mutually exclusive categories nor are they the sole means of classifying self-regulation consequences.

A Self-Regulation Model Including Antecedents, Attributes, and Consequences

Walker and Avant (2011) do not specify creating a model as part of their concept analysis method; however, given the relationships and overlaps identified in preceding sections (i.e., self-efficacy), a visual representation is critical to understanding self-regulation antecedents, attributes, and consequences (Figure 3). There is an adaptation of Walker and Avant's (2011) concept analysis method in this article because a 'crossover' category was created to encompass cognitions and behaviors including information gathering, self-efficacy, and self-control. In Figure 3 these elements are included in the outermost shaded oval to represent that they serve as factors that underlie the self-regulation process and can appear at multiple points throughout the behavior change process, as indicated by the arrows.

Identify a Model Case

Walker and Avant's method of concept analysis requires delineation of attributes through development of cases. A model cases will encompass all of the core attributes of a concept (Walker & Avant, 2011). The case below is an example of a model case.

Kip, a 57-year-old male, is hospitalized after a heart attack. Prior to discharge, he is also diagnosed with new onset congestive heart failure (CHF) and starts to receive in-hospital education from nursing staff regarding managing his disease after discharge. Kip has limited knowledge about this disease and receives new information from the doctors on his case about what causes CHF, the treatments, prognosis, and home management over the 3 days prior to discharge. With increased understanding of the disease and changes that need to be made to his health behaviors if he is to minimize disease progression, Kip meets with the Cardiac Rehabilitation Nurse to develop realistic, self-directed, goals related to his CHF. One of the goals Kip identifies, with the help of the Nurse, is to decrease Kip's high sodium diet (to 2 grams per day) as contributing to potential worsening of his CHF; however, Kip has little confidence that he will be able to identify what foods are high in sodium since he expresses "they sneak salt into everything nowadays" (low pre-action self-efficacy), and Kip tells his healthcare team and nursing staff that he is from a cultural group that cooks using a lot of spices that are high in sodium (values, beliefs, standards; controlling temptations; competing goals). To help increase Kip's confidence that he can change his sodium intake, the nurse helps him complete a hypothetical 3-day food log while in the hospital, and he learns to identify high sodium foods that he has typically eaten (self-monitoring). Kip downloads a smartphone application to help him track his sodium intake once he returns home (preparatory planning). Prior to discharge, Kip creates a month-long meal plan that includes low sodium food options for meals and snacks in addition to flavoring substitutes (action planning). Upon returning home, Kip starts eating a

lower sodium diet (self-management behavior), following his meal plan, and continues to use his smartphone app to track his daily sodium intake as well as logging his meals (self-monitoring). Kip also makes plans for what he is going to do if he doesn't have a low sodium option readily available (i.e., dining out with friends) (coping planning). Kip's food app also allows him to trend the sodium content of his meals over they course of weeks, months, and year, so he can see on what days he is meeting his goal of less than 2 grams of sodium (performance assessment). After a month at home, Kips cardiologists conducts laboratory testing of Kip's blood to help determine his fluid status and cardiac functioning. At this appointment, Kip receives information that his sodium levels and cardiac function are stable (information gathering).

Identify a Contrary Case

Contrary cases provide examples of scenarios that do not depict the concept (Walker & Avant, 2011). Below is an example of a contrary case.

Kip, a 57-year-old male, is hospitalized after a heart attack. Prior to discharge, he is also diagnosed with new onset congestive heart failure (CHF) and starts to receive in-hospital education from nursing staff regarding managing the disease after discharge. Kip has limited knowledge about this disease and receives new information from the doctors on his case about what causes CHF, the treatments, prognosis, and home management over the 3 days prior to discharge. The Cardiac Rehabilitation Nurse tells Kip that the best ways to avoid being readmitted for CHF exacerbations in the future is to limit his water intake, eat fewer foods high in sodium, and engage in a predetermined list of exercises appropriate for his heart condition. Kip does not ask the nurse any questions, but takes the printed materials on CHF that she provides. By his time of discharge from the hospital, Kip has not set any goals or gathered any additional information related to his CHF management.

Comparing the Model and Contrary Cases

The contrary case provides no evidence that the nurse assisted Kip in engaging in the self-regulation process or that Kip made any efforts to initiate the process. Although the nurse cannot change the "have-to" nature of CHF management (e.g., you have to watch out for sudden weight gain, modify diet appropriately, start taking new medications), she does nothing to encourage Kip to make self-directed health behavior changes, and Kip does nothing to establish goals related to his disease management. Although information is provided to Kip by the doctors about the disease, prognosis, and management, other forms of information relevant to Kip making health behavior changes are not considered such as his level of awareness about the disease, pre-existing knowledge, or his standards, values, and beliefs. One or more of these factors would likely have implications for changing Kip's behavior. Kip is essentially presented with three goals, and he is not provided with any direction about how to move towards accomplishing any of these goals. Beyond not assisting Kip in setting his own goals, the nurse does not teach Kip how to engage in self-regulation by utilizing the core attributes of the concept (e.g., planning, action, self-monitoring, performance assessment, self-efficacy [maintenance/coping, recovery]). The model example, in comparison, is focused on helping Kip gain the tools and skills necessary to manage his CHF. From the outset, Kip is empowered by the nurse to set his own goal related to his CHF management, which includes assessing Kip's confidence to reach this goal. Kip also engages in a number of activities that set him on the path to successful health behavior change and maintenance (information gathering, action planning, preparatory planning, self-monitoring, performance assessment).

Defining Empirical Referents

To further clarify self-regulation, it is necessary to extrapolate the empirical referents. Empirical referents are the actual phenomena that allow one to measure the concept in practice,

and may be the same as the defining attributes (Walker & Avant, 2011). The key to empirical testing of the concept of self-regulation lies in the ability to measure a process that is nonlinear, which does not demand that individuals use all constituent steps, and allows them the freedom to repeat steps. As discussed above, there does appear to be somewhat of a chronological progression to self-regulation in that, to the extent individuals engage the steps of the process, motivation is followed by goal-setting, planning, self-monitoring, and performance assessment. There is one tool in the literature that already claims to measure self-regulation, the Self-Regulation Questionnaire (SRQ) authored by Brown, Miller, and Lawendowski (1999). This tool includes items measuring use of self-regulation steps such as receiving relevant information, evaluating the information and comparing it to norms, triggering change, searching for options, formulating a plan, pursuing self-management behaviors, assessing effectiveness of plans. Although this tool does not exactly match the attributes of of self-regulation as described in this concept analysis, there are definite parallels. For example, receiving relevant information and comparing it to norms is similar to information gathering. The SRQ incorporates activities that reflect self-regulation with items such as "I tend to compare myself with other people" (assessment) and "I have trouble making plans to help me reach my goals" (planning). An alternative form of measurement that might be better suited for measurement of a behavior change process that unfolds as individuals are carrying out their daily lives would be Ecological Momentary Assessments (EMA). EMAs involve repeated sampling of subjects' current behaviors and experiences in real time, in subjects' natural environments. EMA has the potential to allow the ecologically valid study of the self-regulation process steps that influence behavior in real-world contexts. Furthermore, qualitative research data may serve to clarify the concept as it is carried out daily by individuals trying to make behavior changes as well as understanding how self-regulation is potentially executed in nursing practice.

Implications for Nursing Care

Using current self-regulation literature, this concept analysis has helped develop a clearer understanding of self-regulation including the concept's definition and salient attributes, antecedents, and consequences. This article also considered how these components potentially relate, overlap, and are illustrated in hypothetical patient scenarios. The vast majority of time and effort dedicated to initiating and/or modifying health behaviors is expended in community settings, as individuals go about their daily routines. Therefore, it is essential for nurses and other healthcare professionals to maximize the opportunities they have to work with individuals trying to self-regulate. Self-regulation has to be individualized to the particular patient and their specific health goals. Although this concept analysis reveals that the literature depicts self-regulation as including some logical steps that flow from one to another (motivation precedes goal-setting, which is followed by planning, self-monitoring, and performance assessment), the process of self-regulation is not unidirectional every time (e.g., self-monitoring can precede goal formation) nor does every attribute, antecedent, and consequence become invoked in every goal pursuit. Also, there appear to be factors that can come into play at any point in the goal pursuit process such as information gathering and different forms of self-efficacy and self-control. Nurses need to be aware that pursuing health goals is not always as simple as "follow Steps 1 thru 5, and repeat as necessary." Nurses can facilitate people in identifying which aspects of self-regulation work for them, recognizing how self-regulation manifests in their daily lives, and continually progressing toward goal achievement.

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Summary of Chapter 1

The purpose of Chapter 1 was to introduce the problem of understanding how people initiate and maintain health behavior changes. This chapter identified that although scholars have theoretically defined processes of change, there is limited knowledge of the activities individuals actually engage in as they try to achieve their health goals. The particular process of focus in this dissertation was self-regulation, simply characterized as the activities people take in pursuing their health goals. The current descriptive study used secondary analysis to identify the self-regulation activities that people engage in over time related to four osteoporosis prevention areas (calcium intake, balance, strength and physical activity). Prior to conducting secondary analysis, the concept and current empirical understanding of self-regulation required further examination. Reviewing self-regulation literature from the past five decades reveals that the concept has often been ambiguously and inconsistently described. The purpose of Manuscript 1 was to increase conceptual clarity of self-regulation by delineating a definition and identifying the concept's antecedents, attributes, and consequences. Chapter 2 turns a critical eye towards contemporary self-regulation intervention studies focused on promoting health behaviors change.

CHAPTER 2

Review of Literature

Chapter 2 includes a systematic review self-regulation interventions focused on health behaviors change. The intention of including such a review in this dissertation is to seek further understanding and clarification of how self-regulation has been applied to health behavior change research to date, with the additional aim of supporting this author's decision to use secondary data analysis to describe the self-regulation process as it actually unfolds. Prior to the systematic review, Chapter 2 considers two closely related concepts, self-regulation and self-management, that are frequently discussed as one and therefore require differentiation.

Distinguishing Self-Management from Self-Regulation

Examining the self-management studies that have been published in recent years, aspects of self-regulation consistently appear, though they may manifest differently in terms of which dimensions of self-regulation are emphasized or included. In a self-management RCT conducted by Vinkers, Adriaanse, Kroese, and de Ridder (2014), a group of participants received a self-management intervention aimed at weight control. The intervention consisted of teaching participants to set personally relevant, realistic dietary goals, explore barriers to goal attainment, and make specific plans for initiation of action (p. 784). Results of the study demonstrated that participants in the intervention group had improved BMIs at 1-year follow-ups as compared to the control group, and these participants also had higher proactive coping skills scores (e.g., rated themselves higher in terms of being able to make goal-related plans, respond to obstacles, etc.). Baig et al. (2015) implemented a self-management intervention in an RCT that included Latino individuals with diabetes. Their intervention included teaching participants behavioral problem-solving strategies including goal-setting, anticipating likely obstacles, identifying behavioral alternatives, and stimulus control (p. 1482). Results from Baig et al. (2015) did not demonstrate

statistically significant differences in terms of diabetes-related health outcomes (weight, glycosylated hemoglobin A1C, LDL cholesterol); however, participants in the intervention group reported less high fat food consumption and more exercise than the usual care group at the 1-year follow-up appointment. A theory-driven osteoporosis prevention study by Ryan et al. (2013) included self-regulation skills (goal-setting, self-monitoring, reflection, plan enactment, and evaluation) as part of a computer-based self-management intervention targeting women ages 40 to 60. The study results demonstrated that participants in the self-management group achieved higher levels of calcium intake than women in the usual care group.

Studies from Vinkers et al. (2014), Baig et al. (2015), and Ryan et al. (2013), exemplify that self-regulation, in various forms, appears as threaded throughout the self-management literature in studies that range in health focus from weight control to diabetes to osteoporosis. However, the application of self-regulation appears inconsistent, and perhaps this is owing to the fact that in reviewing the self-management literature that so often incorporates self-regulation into its 'self-management interventions,' we are missing a more complete understanding of self-regulation that could be gained from specifically considering what are identified as *self-regulation* interventions. In an effort to analyze self-regulation as separate from self-management, the purpose of Manuscript 2 is to describe self-regulation as it appears in studies identified as "self-regulation interventions."

Manuscript 2

In Chapter 1, a concept analysis of self-regulation is presented that utilizes health behavior change literature to delineate a cogent definition of the concept and identify its constituent antecedents, attributes, and consequences. Further understanding of self-regulation is sought in Manuscript 2 by analyzing how researcher-identified "self-regulation interventions" describe and operationalize the concept. This systematic review of self-regulation interventions will be submitted to the peer-reviewed journal *Journal of Nursing Scholarship* for consideration. The manuscript is written according to the author guidelines provided at the journal's home website. It is written according to the Publication Manual of the American Psychological Association (APA) Sixth Edition (2010) reference and citation requirements.

Manuscript 2

Title: Systematic Review of Self-Regulation Interventions Targeting Health Behavior Change

Abstract

Although self-regulation is a concept frequently incorporated into health behavior change interventions, it is indeterminate how comprehensive or consistent these interventions are in terms of their treatment of self-regulation and how effectively they alter health-related outcomes. The aim of the current study is to analyze contemporary studies described by authors as "self-regulation interventions" to assess the self-regulation activities incorporated into these interventions in addition to their effectiveness at achieving health-related outcomes including self-management behaviors such as symptom control and health-promoting behaviors (physical activity, diet modification, smoking cessation). A systematic review of self-regulation intervention studies and health-related outcomes was conducted for studies focusing on adults engaging in health behavior change. The electronic databases of CINAHL, Medline, PsycInfo, and Academic Search Complete were searched using the keywords of self-regulation and health behavior. Studies included were randomized controlled trials that tested the effects of at least one self-regulation activity, according to the general self-regulation activities identified by Bandura (2005). Quality assessment was conducted using the six domains from the Cochrane Collaboration's risk of bias tool: random sequence generation, allocation concealment, blinding of outcomes assessment, incomplete outcome data, selective reporting, and other bias. Eleven interventions studies were included in the final review. Across the 11 studies, successful engagement in health-related outcomes was inconsistently achieved. For intervention content, there was wide variability in the self-regulation activities that researchers included in the interventions (e.g., goal-setting, planning, and self-monitoring were routinely utilized but intervention uniformity in terms of self-regulation activities were otherwise erratic). These

irregularities were indicators that our comprehension and application of self-regulation has not progressed to the point of successfully designing interventions aimed at altering health behaviors.

In the burgeoning world of patient-centered health care, self-regulation is a concept of increasing interest to individuals trying to develop interventions that promote health behavior change and prevent disease. Healthcare structures are increasingly drifting away from a philosophy where professionals dictate instructions that patients blindly follow. In a consumer-driven market, people are expected to actively direct their health behaviors, selecting their own goals and pursuing them in collaboration with members of a healthcare team and other social supports.

In this climate that encourages active decision-making and participation, a person's ability to self-regulate is proposed as a significant factor influencing how effectively he or she translates motivation to change a behavior into actual behavior change. Self-regulation is commonly defined as a process of human behavior that entails setting of personal goals and directing behavior toward the achievement of those goals. The goals are mental representations of desired states or outcomes. The exact components of self-regulation vary depending on the theory or model being consulted. Nevertheless, Bandura (2005) identified three commonalities that pervade: (a) adoption of goals and strategies to achieve them, (b) self-monitoring of health-related behavior and the social and cognitive conditions under which one engages in change, and (c) enlistment of self-motivating incentives and social supports to sustain health practices.

The role of self-regulation in moving individuals from behavioral intentions to actions has prompted the emergence of self-regulation intervention studies. A review of self-regulation assessments and interventions was conducted by Maes and Karoly (2005). In their review, Maes and Karoly report finding a limited number of self-regulation interventions that are sound in terms of the self-regulation theories they are based on and the comprehensiveness of the interventions. They conclude that most self-regulation interventional studies use broad-based instructional materials and focused on limited aspects of self-regulation (Maes & Karoly, 2005).

The purpose of this article was to present a systematic review of self-regulation interventions for adults pursuing health behaviors changes in order to: (a) describe self-regulation activities included in the interventions, and (b) describe the effects of the interventions on the health-related, including self-management, and self-regulation-specific outcomes.

Method

A systematic review of self-regulation activities and health-related outcomes for self-regulation interventions was conducted using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher, Liberati, Tetzlaff, & Altman, 2009). For this review, targeted health-related outcomes of concern include health promoting behaviors for studies not emphasizing a particular disease state (e.g., fruit and vegetable intake, physical activity, decreased sodium intake, weight and BMI control, blood pressure control). For studies investigating an intervention related to a particular disease activity (e.g., asthma, cardiovascular disease, end stage renal disease), disease activity and symptom management were the health-related outcomes of interest. Additionally, this review also examined studies for outcomes related to participant engagement in self-regulation activities.

Search Strategy

Cumulative Index to Nursing and Allied Health Literature (CINAHL), Medline, PsycInfo, and Academic Search Complete databases were used to search the literature. Search terms included "self-regulation intervention" AND "health behavior." Additional selection criteria included: study participants age 18 and older; studies published in English; and randomized controlled trials that tested the effects of at least one self-regulation skill, according to the general self-regulation activities identified by Bandura (2005). Reports that included only children or adolescents were excluded. To ensure that current intervention studies were considered, publications between January 2000 and September 2018 were included in this

review. A targeted, hand search of the bibliographies of papers meeting the inclusion and exclusion criteria was also conducted to identify additional relevant studies.

Intervention Selection and Data Extraction

All of the titles and abstracts were reviewed and potentially relevant articles identified. Next, all potentially relevant articles were read in full text and the final studies included in the review were identified. Data were extracted and organized into a literature table (Table 1). The main fields included authors, year of publication, country, participant information (e.g., age, gender, sample size), intervention details (format, content, time frame, theoretical background), outcome measures, main findings, and self-regulation components of intervention.

Quality Assessment

Quality assessment was conducted using the six domains from the Cochrane Collaboration's risk of bias tool: random sequence generation, allocation concealment, blinding of outcomes assessment, incomplete outcome data, selective reporting, and other bias (i.e., power and use of intention to treat analysis; Higgins & Green, 2008). All domains were evaluated for risk for potential bias (high, low, or unclear risk due to incomplete reporting; Higgins & Green, 2008).

Results

Study Characteristics, Samples, and Settings

Figure 1 contains the details of the article selection process based on the inclusion and exclusion criteria outlined in the Method section. Six hundred and thirty-five studies were identified. Eleven studies, published between 2002 and 2018, met the study criteria.

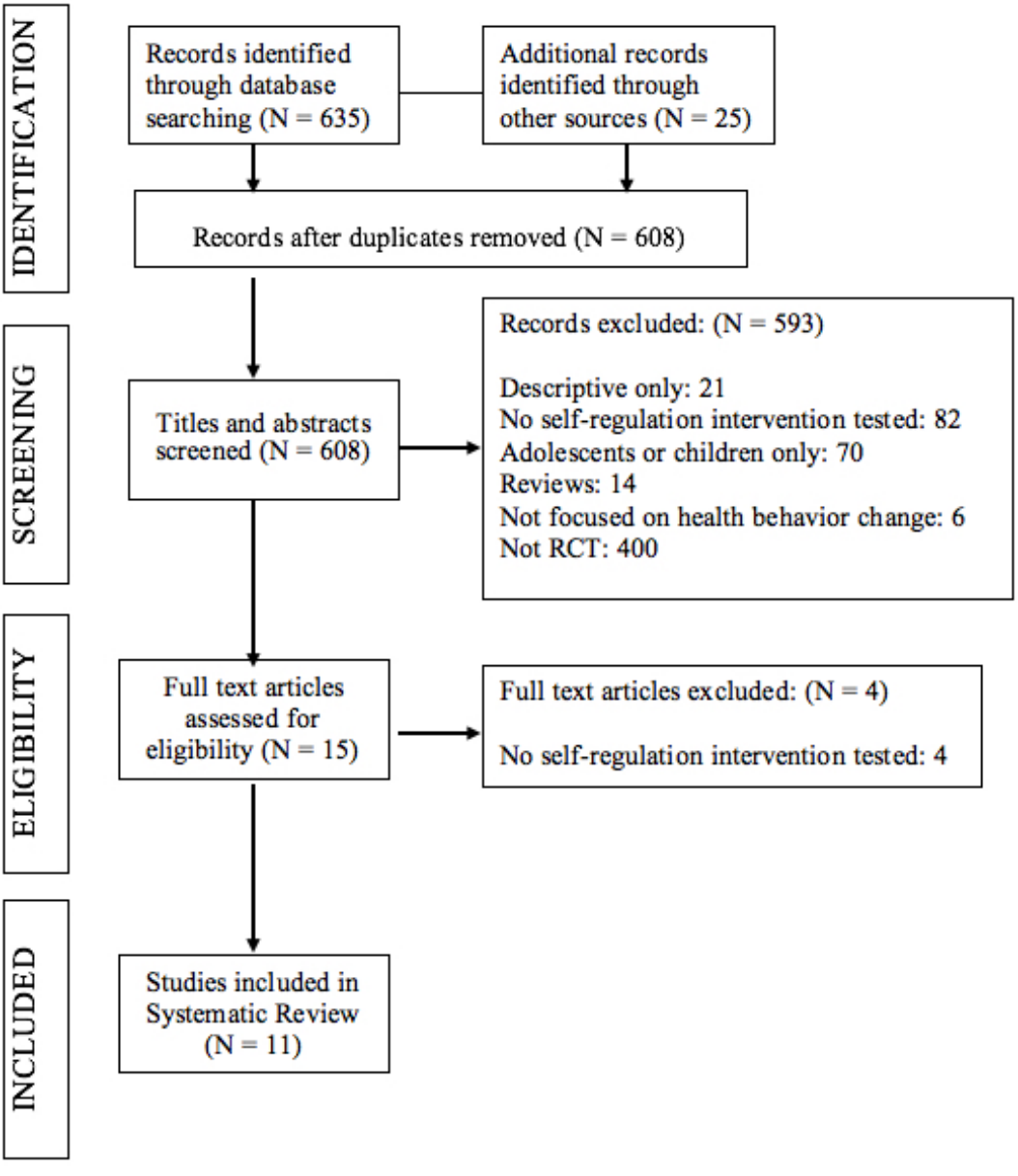

Figure 1. PRISMA-based flow of studies for systematic review

All studies were randomized controlled trials with the exception of one quasi-experimental design utilizing matched controls for patient recruited from hemodialysis clinics (Christensen, Moran, Wiebe, Ehlers, & Lawton, 2002). The samples had diverse clinical and demographic characteristics, outcomes, and study quality. Table 1 includes a column providing

details describing study interventions. There were a total of 1,971 participants (n = 27 to 791 per trial) who completed a self-regulation intervention, with ages ranging from 18 to 80 years old.

The self-regulation interventions were delivered in a variety of settings, including hospitals and clinics (Christensen et al., 2002; Marques, Gucht, Leal, & Maes, 2015), outpatient rehabilitation programs (Janssen, De Gucht, Van Exel, & Maes, 2014; Sniehotta, Scholz, & Schwarzer, 2005), on the Internet (Dorough et al., 2014; Lange et al., 2013; Winett et al., 2011), community-based centers (Stadler, Oettingen, & Gollwitzer, 2010), universities (Lhakhang, Lippke, Knoll, & Schwarzer, 2015; Rameshbabu, Reddy, & Ports, 2018), and in a combinations of environments (e.g., in-person group sessions and phone contact: Baptist, Ross, Yang, Song, & Clark, 2013). The studies also took place in a variety of locations including the United States (Baptist et al., 2013; Christensen et al., 2002; Dorough et al., 2014; Rameshbabu et al., 2018; Winett et al., 2011), the Netherlands (Janssen et al., 2012), Germany (Lange et al., 2013; Sniehotta et al., 2005; Stadler et al., 2010), India (Lhakhang et al., 2015), and Portugal (Marques et al., 2015). Studies ranged in follow-up periods from 8 weeks (Christensen et al., 2002) up to 24 months (Stadler et al., 2010).

Table 1.

Summary of Designs, Interventions, Findings, and Self-Regulation (SR) Skills and Abilities

Author(s), Year, Country	Participants, age, gender, sample size, design, power calculation	Intervention format (F), Theory-basis of Intervention (T) content (C), length (L)	Target Behavior (TB) Concept Measured (C), Tool (T), Assessments Times (AT)	Main Findings	Self-Regulation Activities Included in Interventions (bolded), other intervention details (ID)
Baptist et al. (2013) US	older adults with persistent asthma recruited from a tertiary care center Age: mean 72.8 (intervention), 73.8 (control) Gender: 23% female (intervention), 31% female (control) Sample size: 70 (34 intervention; 36 control) Design: RCT – Two arm trial (intervention and control) Power: study completion by 58 participants (29 participants per arm) would provide 80% power to detect a difference between groups of 0.75	F: three in-person group sessions (7 participants and a health educator) and three one-on-one telephone sessions. T: social cognitive theory of behavior change; self-regulation process C: participant selected asthma-related problem; observed (peak flow meter readings and asthma symptoms) and researched own routine to see how asthma was preventing resolution of this problem; identified and developed plan to address problem. Intervention was self-directed, with personalized assistance from the health educator all participants received standard asthma education (proper inhaler technique, asthma triggers, assessment of asthma control, and signs of an asthma exacerbation) L: 6-week asthma intervention	TB: asthma self-regulation C: asthma quality of life T: mini-Asthma Quality of Life Questionnaire (mAQLQ) C: Asthma control T: Asthma Control Questionnaire (ACQ) C: healthcare utilization T: emergency department, hospital or unscheduled physician visits due to asthma (over course of 6 months) Other Tools: exhaled nitric oxide, corticosteroid courses, and percentage of predicted forced expiratory volume in 1 second (FEV1%)	mAQLQ score significantly higher in intervention group than control at 1, 6, and 12 months. ACQ was better in the intervention group than in the control group at 1, 6, and 12 months. Healthcare utilization was lower in the intervention group, although no difference was observed in FENO or predicted FEV1% Self-regulation intervention effective for improving asthma QoL, asthma control, and healthcare utilization in older adults.	**Goal-setting** – select a specific, asthma-related problem **Observe/research routine** – ppt using peak flow meter to monitor readings and asthma symptoms **Develop Plan** to achieve goal

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			AT: 1, 6, 12 months		
Christensen et al. (2002) US	Adults recruited from six hemodialysis centers in Midwest Age: 53.65 (intervention); 56.47 (control) Gender: 55% female in both arms Sample Size: 40 (20 in each arm) Design: quasi-experimental design, ppts from three centers participated in the behavioral self-regulation groups; ppts in the other three centers served as matched controls (matched on gender, diabetic status, average interdialysis weight gain at baseline, and age) Power: no power	F: Groups of 4–6 participants meeting for hour-long weekly sessions. Groups lead by therapist with advance degree in clinical psychology; therapist-directed sessions with emphasis on self-regulation In addition to group discussion, there were homework assignments (practice in self-monitoring and goal-setting) T: Kanfer's self-regulatory framework of self-monitoring, self-evaluation, and self-reinforcement of a target behavior (Kanfer & Gaelick, 1986) L: 7-week intervention	TB: fluid-intake adherence T: interdialytic weight gain (IWG); IWGs greater than 2.5 kg are generally considered indicative of problematic weight gain AT: Baseline, End of Intervention, 8 weeks post intervention	Main effects for both Group, $F(1, 38) = 0.93$, $p > .30$, and Time $F(2, 37) = 0.10$, $p > .50$, were non-significant. Group x Time interaction was significant, $F(2, 76) = 3.72$, $p > .05$. Intervention-group patients displayed a pattern of decreased IWG over time whereas control patients displayed a pattern of increased IWG	SR: Instruction in **self-monitoring** and homework of monitoring fluid intake **Goal-setting** regarding fluid intake **Self-evaluation:** weekly evaluation of target behavior performance and IWG relative to goals ID: Ppts instructed in rationale and overview of self-regulation process; teaching stimulus control, self-instruction, and behavioral coping skills to promote regulation of fluid intake

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	analysis prior to study period. Post hoc power analysis showed a sample of approximately 65 would be needed to obtain statistical power at the recommended .80 level				
Dorough, et al. (2014) US	Adults with prehypertension Age: range 45-65; mean 54.3 Gender: 69.5% female Sample size: 27 (12 in Dash 2 Wellness only arm (standard of care): 15 in Dash 2 Wellness plus) Design: RCT; ppts randomized to DASH 2 wellness only standard of care or to DASH 2 wellness plus Power: no power analysis	F: electronic communication/information in the form of weekly newsletters (Wellness Newsletter) T: social-cognitive theory of self-regulation C: Both groups received instruction on the DASH eating plan, instructions to increase steps per day, and use of a weight scale and pedometer. DASH 2 Wellness (D2W) plus received additional training related to self-regulation (e.g., self-monitoring fruit and vegetable intake, daily weights, step count, goal-setting, weekly feedback on progress to goals) L: 10-week intervention	TB: physical activity T: step count measured with pedometer and scale TB: fruit and vegetable intake and sodium intake T: 4-day food record Other Tools: blood pressure, weight, and BMI AT: baseline and Week 11 (intervention was 10 weeks)	D2W plus (intervention) showed a larger increase in daily steps (M = 2,900) than D2W only (M = 636); a larger decrease in systolic BP (mmHg), M = 15.1 versus M = 4.6, and a larger decrease in weight (in kg), M = 4.8 versus M = 1.5 Primarily electronically delivered approach was more effective than the standard of care in changing some health behaviors related to nutrition and PA, reducing body weight, and reducing SBP. No significant differences and moderate effect-size estimates for consumption of sodium and fruits and vegetables	SR: **Goal-setting** **Planning** **Tracking** ID: social support, stress management, enjoyment, positive self-talk and thinking Tailored feedback provided to ppts electronically based on ppts reported activities from the previous week

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Summary of Designs, Interventions, Findings, and Self-Regulation (SR) Skills and Abilities

Author(s), Year, Country	Participants, age, gender, sample size, design, power calculation	Intervention format (F), Theory-basis of Intervention (T) content (C), length (L)	Target Behavior (TB) Concept Measured (C), Tool (T), Assessments Times (AT)	Main Findings	Self-Regulation Activities Included in Interventions (bolded), other intervention details (ID)
Janssen, et al. (2014) Netherlands	Adults with recent completion of a cardiac rehabilitation program Age: 56.6 (intervention); 58.8 (control) Gender: females 21.6% (intervention); 15.6% females (control) Sample size: 210 Design: RCT; ppts randomized to receive either a lifestyle maintenance program (n=112) or standard care (n= 98). Power: Power analysis showed that a sample of 164 patients would be sufficient to detect an effect size of at least 0.1 with 80 % power at the 5 % significance level	F: 1-hr motivational counseling session w/health psychologist to explore recovery goals, 7 group sessions aimed to enhance self-regulation, home assignments. T: cognitive-behavioral learning theory C: During motivational interview, ppt health goals explored and set. Potential barriers to goal achievement, and costs and benefits of change were examined. Ppts then attended weekly 2-hr group session also lead by health psychologist Group sessions focused on self-regulation skills: self-monitoring their goal-related behavior, developing specific action plans, forming realistic outcome expectancies, obtaining progress-related feedback, and discussing problem-solving strategies Ppts in the control group had 1-hr individual interview with a health psychologist, for goal	TB: Exercise behavior T: step counts measured via pedometer TB: dietary behavior T: 56-item dietary questionnaire asking about fat, fruit, and vegetable intake TB: Self-regulation skills T: Self-Regulation Skills Battery AT: baseline (T1), 6 months (T2), 15 months (T3)	Regarding exercise behaviors, mean change in the intervention group was +1,065 steps per day from T1 to T3. In the control group this was respectively 233 steps per day. No significant group differences for dietary behavior (fat intake and fruit & vegetable intake) At T2, the intervention group reported higher scores on the Self-Regulation Skills Battery (M=17.07, SD=1.67) as compared to the control group (M=16.54, SD=1.60) A significantly greater proportion of ppts in the lifestyle intervention group adhered to recommended levels of physical activity. The lifestyle group reported improved self-regulation skills as compared to the control group and mediation analysis demonstrated that the effect on physical activity could be	SR: **Goal-setting** **Planning** **Self-monitoring** **Emotional control** ID: Information on consequences of unhealthy behaviors, forming realistic outcome expectancies, problem-solving strategies, receiving progress-related feedback, social support, coping planning, rewards contingent on success, stress management

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Author(s), Year, Country	Participants, age, gender, sample size, design, power calculation	Intervention format (F), Theory-basis of Intervention (T) content (C), length (L)	Target Behavior (TB) Concept Measured (C), Tool (T), Assessments Times (AT)	Main Findings	Self-Regulation Activities Included in Interventions (bolded), other intervention details (ID)
		identification. The interview was not followed-up by group sessions L: 19-week intervention period		explained by self-regulation skills. .	
Lange et al. (2013) Germany	Adults recruited via radio, newspaper, TV advertisements Age: mean 37.73 (range 14-79) Gender: 79% women Sample size: 791(392 intervention; 399 control) Design: RCT Power: no power analysis reported	F: online intervention to promote fruit consumption T: called a 'theory-drive' intervention but no theory identified C: intervention group promoted dietary planning and action control. Ppts asked to commit to a specific personal goal with regard to fruit consumption; identify a plan for accomplishing their goals (including preparatory behaviors like buying and preparing fruit). In written vignettes, role models identified five common situations that may pose a challenge and provided solutions to overcome these obstacles. Ppts then had to identify up to three personal barriers and strategies to overcome them.	TB: Fruit intake T: open-ended questionnaire TB: Dietary planning T: 2-question survey TB: Dietary action control T: 3-question survey	Repeated measures analyses comparing intervention and control groups at pre-test and post-test revealed significant time by group interactions for all three dependent variables: fruit consumption, dietary planning and action control. Ppts receiving the intervention consumed more fruit than participants in the control condition. The same kind of effect emerged for the social–cognitive predictors, namely dietary planning and action control.	SR: **Goal-setting** **Planning** (including preparatory planning) **Action control/Self-monitoring** (ongoing behavior is retrospectively evaluated with regard to a behavioral standard) ID: identifying potential obstacles to goal achievement and strategies to overcome
Lhakhang et al.,	University students recruited from	F: interventionist resided with ppts during study period and	TB: Hand-washing	Both intervention resulted in increased hand-washing	SR:

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Author(s), Year, Country	Participants, age, gender, sample size, design, power calculation	Intervention format (F), Theory-basis of Intervention (T) content (C), length (L)	Target Behavior (TB) Concept Measured (C), Tool (T), Assessments Times (AT)	Main Findings	Self-Regulation Activities Included in Interventions (bolded), other intervention details (ID)
2015 India	residence hall in New Delhi, India Age: mean age 20.71 (range 18-26) Gender: 52% female Sample size: 205 Design: longitudinal, cross-over design w/cluster randomization. Ppts randomized to two interventions groups and no control. Testing efficacy of two intervetnions Power: no power analysis reported	observed students engaging in the intervention modules. Each intervention session lasted 20 minutes, and was delivered by author and four research assistants T: Health Action Process Approach C: Mot-SelfR group received first a motivational intervention ('Mot': risk perception and outcome expectancies) followed by a self-regulatory intervention 17 days later ('SelfR': perceived self-efficacy, action planning [including timing, frequency, and technique for hand-washing], coping planning [barrier identification and problem-solving]). SelfR-Mot group received the same two intervention modules in the opposite order. 'Mot' also include information of regarding why and how to wash hands; risks of not washing; positive outcome expectancies	T: self-reported hand-washing frequency reported via survey C: Behavior intention to hand-wash T: 2-item survey C: Self-efficacy T: 6-item survey C: Planning T: 6-item survey AT: Follow-up data were assessed 17 days (Time 2) (end of intervention) and 34 days (Time 3) after the baseline (Time 1)	frequency, intention, self-efficacy, and planning. Within groups, the self-regulatory module was more effective than the motivational module, independent of sequence (at T3, after both groups had received all intervention modules [only in opposite order] the difference between the Mot-SelfR group and the SelfR-Mot group was not significant F (1, 197) = 0.71, p = .40)	**Goal-setting (goal set for ppt: increase handwashing)** **Planning (Action and Coping)** **Self-efficacy in following through with plan** ID: information provided and how to perform the behavior and why (benefits); risks of not washing; risk perception; positive outcome expectancies of hand-washing

Table 1.

Summary of Designs, Interventions, Findings, and Self-Regulation (SR) Skills and Abilities

Author(s), Year, Country	Participants, age, gender, sample size, design, power calculation	Intervention format (F), Theory-basis of Intervention (T) content (C), length (L)	Target Behavior (TB) Concept Measured (C), Tool (T), Assessments Times (AT)	Main Findings	Self-Regulation Activities Included in Interventions (bolded), other intervention details (ID)
		L: 17 days			
Marques et al. (2015) Portugal	Adults who met Center for Disease Control criteria for idiopathic chronic fatigue (unexplained fatigue of at least 6 months duration) recruited from Portuguese health care centers Age: mean age 48 Gender: 97.8% women Sample size: 91 (45 intervention and 46 control) Design: RCT; assessing efficacy of self-regulation-based physical activity program for patients suffering from unexplained chronic fatigue, the "4-STEPS to control your fatigue program"; control condition was	F: intervention delivered by one trained health psychologist with motivational interviewing training. Two, 1-hr face-to-face motivational interview sessions aimed at promoting self-regulations skills listed in Content below; two brief SR-based telephone counselling sessions (weeks 5 and 9). Ppts in intervention also had a self-regulation workbook for self-regulation skill practice. T: no theory identified, even though intervention labeled 'theory-based' C: focused on goal selection and setting, action planning, self-monitoring, self-efficacy, motivation, control over competing goals, coping planning, emotional regulation, control over distracting stimuli, relapse prevention, goal reformulation L: 12 weeks	C: fatigue severity (primary outcome) T: Portuguese adaptation of the Checklist of Individual Strength (CIS20-P) C: fatigue impact T: Brief Pain Inventory (BPI) TB: physical activity T: leisure time physical activity, number of daily steps and personal activity goal progress measured via pedometer and Short Questionnaire to Assess Health-Enhancing Physical Activity (SQUASH) C: health-related quality of life T: Short Form Health Survey-12 (SF-12V.2) C: somatic distress and	At post-treatment, significant difference for subjective experience of fatigue (4.73 points; g=0.51) in favor of the intervention group. Mixed design ANCOVAs showed a significant effect of the 4-STEPS on fatigue severity, leisure time physical activity, personal activity goal progress and health-related quality of life. No significant effects were found for number of daily steps and somatic and psychological distress	SR* **Goal Selection** **Goal Setting** **Action Planning** **Self-monitoring** **Coping planning** **Self-efficacy** **Motivation** **Emotional Control** **Control of Competing goals** **Control over distracting stimuli** **Relapse prevention** **Goal reformulation** *authors did not clearly delineate which intervention components were self-regulatory and which were not

Table 1.

Summary of Designs, Interventions, Findings, and Self-Regulation (SR) Skills and Abilities

Author(s), Year, Country	Participants, age, gender, sample size, design, power calculation	Intervention format (F), Theory-basis of Intervention (T) content (C), length (L)	Target Behavior (TB) Concept Measured (C), Tool (T), Assessments Times (AT)	Main Findings	Self-Regulation Activities Included in Interventions (bolded), other intervention details (ID)
	standard care (received a flyer with information about health benefits of physical activity and guidelines for adults; set a physical activity goal) Power: a priori analysis - sample of 34 ppts in each group sufficient to detect a mean difference of 7 points between intervention and control group on subjective experience of fatigue dimension of the CIS20-P, w/ 80 % power, 5 % significance level		psychological distress (depression and anxiety) T: Patient Health Questionnaire-15 (PHQ-15) and Brief Symptom Inventory (BSI) AT: baseline, 12 weeks (post intervention)		
Rameshbabu et al., (2018) US	Custodial workers at a Midwestern university Age: mean age 50.86 (range 27-69) Gender: 50% women Sample size: 54 (27 ppts in each group)	F: Facilitator meet with ppt in 1:1 sessions. Self-regulation intervention training began with self-monitoring during week 1 and was followed by goal setting, problem-solving, self-rewarding, and self-evaluation and goal revision starting the second week. Outside of sessions, intervention	TB intake of foods high in saturated fats T: weekly checklist measuring intake of the most common sources (or food categories) of saturated fat C: use of self-regulation for controlling fat intake	Intervention group reported lower saturated fat intake and greater self-regulation than the Education Only group throughout the intervention period and higher self-efficacy at week 6. However, at follow-up (T3), there was a decrease in self-	SR: **Self-monitoring** **Goal-setting** **Problem-solving** **Self-rewarding** **Self-evaluation** **Goal revision** ID: education regarding the risks of foods high in saturated fats

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Summary of Designs, Interventions, Findings, and Self-Regulation (SR) Skills and Abilities

Author(s), Year, Country	Participants, age, gender, sample size, design, power calculation	Intervention format (F), Theory-basis of Intervention (T) content (C), length (L)	Target Behavior (TB) Concept Measured (C), Tool (T), Assessments Times (AT)	Main Findings	Self-Regulation Activities Included in Interventions (bolded), other intervention details (ID)
	Design: RCT w/ 2 groups. Testing efficacy of an Education + Self-Regulation intervention against an Education Only condition in reducing saturated fat intake among custodial workers Power: a priori power analysis - minimum of 44 individuals (22 per condition) required to detect a medium size effect.	ppts recorded their daily saturated fat food intake on the food diary and self-regulation activities on worksheets provided T: no self-regulation theory specified for intervention development C: both groups received an education booklet on health hazards of a high saturated fat diet along with healthy food recommendations Education + Self-Regulation keep food diaries and self-regulation worksheets to track their use of self-regulation skills L: 4 weeks – 1-hour weekly sessions	T: 10-item self-regulation measure adapted from previous study C: self-efficacy for controlling fat intake T: 5-item self-efficacy measure adapted from previous study AT: baseline (T0), 4 weeks (T1), 6 weeks (T2) and 6 months (T3)	regulation accompanied by an increase in saturated fat intake among Education + Self-Regulation ppts. Education + Self-Regulation ppts continued to report lower saturated fat intake relative to their baseline at 6 month follow-up	
Sniehotta et al. (2005)	Patient with coronary heart disease recruited from three rehabilitation centers near Berlin after undergoing 3-4 weeks of cardiac rehabilitation, in-patient (exercise training and sessions	F: planning booklet and written materials to promote self-regulation skills in goal-setting and planning for physical activity; mailed diaries ppts kept weekly for 6 weeks T: Carver and Scheier (1998); Gollwitzer (1999)	TB: physical activity T: Kaiser Physical Activity Survey and participants had to report perceived strain of exercise C: behavior intentions T: 6-item scale adapted from previous study	Coping planning and action control were significantly higher in the two treatment groups than in the control group. both intervention groups showed higher levels in coping planning, the planning plus diary group was highest in action control	**Behavioral intentions*** **Action planning** **Coping planning** **Action Control** (consists of **awareness of one's own standards**, **self-monitoring**, **regulatory means and effort** exerted when standards and

Table 1.

Summary of Designs, Interventions, Findings, and Self-Regulation (SR) Skills and Abilities

Author(s), Year, Country	Participants, age, gender, sample size, design, power calculation	Intervention format (F), Theory-basis of Intervention (T) content (C), length (L)	Target Behavior (TB) Concept Measured (C), Tool (T), Assessments Times (AT)	Main Findings	Self-Regulation Activities Included in Interventions (bolded), other intervention details (ID)
	including weight lifting, cycling, walking) Age: mean 57.7 (range 31-80) Gender: 81.5% men Sample size: 240 Design: 3-group RCT; standard rehabilitation care and 2 intervention groups; Three groups were planning, planning plus diary, and standard care control Power: no power analysis reported	C: both the planning and planning plus diary received planning booklet with worksheets to develop goal and plan to achieve. Planning plus diary also kept weekly diary for 6 weeks after intervention asking them to track their behavior related to their goals, planning, and actual physical activity behaviors L: 6 weeks	C: self-efficacy T: Exercise Self-Efficacy Scale C: planning T: two planning subscales from previous study C: action control: T: assessed using previous study scale AT: 2 weeks into cardiac rehabilitation program (T1), 2 months after rehabilitation ended (T2), 4 months after rehabilitation ended (T3)	At T2, general physical exercise in the planning group was only slightly higher than in the planning plus diary group but significantly higher than in the control group. Recommended strenuous exercise was highest in the planning plus diary group.	observed behaviors do not match) ID: self-efficacy *described in similar terms as 'goal-setting' included in other interventions within this table
Stadler et al. (2010) Germany	Middle-aged women recruited via mail through German health insurance company Age: mean 41.29 (range 30-50) Sample size: 255	F: one meeting of ppts with a trained female interventionist in groups of two to five women or individually. Sessions lasted 2 hrs T: numerous self-regulation frameworks cited, but none delineated as the framework for intervention. Refers tp intervention as integrating "cognitive-behavioral	TB: weekly fruit and vegetable consumption T: diaries of food intake kept by ppts according to 7-day intervals AT: baseline, and in the first week, 1, 2, 4, and 24 months after intervention.	Ppts in both groups ate more fruits and vegetables (0.47 to 1.00 daily servings) than at baseline during the first 4 months after intervention Two years later, ppts in the information plus self-regulation group maintained the higher intake, whereas participants in the information	**Mental contrasting*:** includes 'identifyng important wish' (goal setting); imagine positive outcome of changing behavior; identifying most critical obstacle **Implementation intention****

Table 1.

Summary of Designs, Interventions, Findings, and Self-Regulation (SR) Skills and Abilities

Author(s), Year, Country	Participants, age, gender, sample size, design, power calculation	Intervention format (F), Theory-basis of Intervention (T) content (C), length (L)	Target Behavior (TB) Concept Measured (C), Tool (T), Assessments Times (AT)	Main Findings	Self-Regulation Activities Included in Interventions (bolded), other intervention details (ID)
	Design: 2-group RCT, longitudinal, study tested whether an intervention that combined information with self-regulation strategies had a better effect on eating fruits and vegetables than an information-only intervention Power: no power analysis reported	components") C: two groups: information only and information + self-regulation (i.e., mental contrasting with implementation intentions). Information was written materials and a post-test regarding fruit and vegetable consumption recommendations and health benefits. Info + self-regulation included information on self-regulation skills of mental contrasting and implementation intention in a specified order and ppts practiced (wrote down wish regarding diet, most positive possible outcome, most critical obstacle, formed 3 implementation intentions, including a way to address obstacle). L: 24 months		group returned to baseline levels	*authors indicate there is an order to mental contrasting – identifying positive expected outcome and then obstacle **described by authors as the details of when, where, and how a behavior will be accomplished – referred to as 'planning' in other articles
Winett et al. (2011) US	Ppt profile: sedentary to low active, high normal weight to obese, but otherwise healthy adults. Recruited from paper and onlne advertisements	F: web-based Guide to Health (WB-GTH). C: Consisted of 52 weekly Social cognitive theory-based modules (5-10 minutes to complete). Modules 1-5 focused on self-efficacy and self-regulation strategies; Modules 6-	TB: physical activity (PA) T: step count assessed via pedometer TB: nutrition T: fruit and vegetable intake assessed Block 2005 Food Frequency	Participants in both Basic and Enhanced at follow-up increased physical activity by about 1,400 steps/day, lost about 3% of bodyweight, and increased F&V by about 1.5 servings/ day.	SR: **Goal-setting** **Planning** **Self-monitoring** **Feedback** ID: self-efficacy, social support

Table 1.

Summary of Designs, Interventions, Findings, and Self-Regulation (SR) Skills and Abilities

Author(s), Year, Country	Participants, age, gender, sample size, design, power calculation	Intervention format (F), Theory-basis of Intervention (T) content (C), length (L)	Target Behavior (TB) Concept Measured (C), Tool (T), Assessments Times (AT)	Main Findings	Self-Regulation Activities Included in Interventions (bolded), other intervention details (ID)
	Age: mean age 44 (range 18–63) Gender: 87.5% female Sample size:86 (control group) 79 (intervention) Design: RCT with two groups: basic and enhanced. Testing the efficacy of web-based Guide to Health only (WB-GTH-Basic) or WB-GTH-Enhanced intervention. Content, overall target behaviors, program goals, and strategies were the same in the two groups. Basic included a generic feedback and planning approach and Enhanced included tailored planning and feedback. Power:	16 focused on outcome expectancy, gaining social support, fostering physical activity enjoyment. Modules 17-52 focused on continued self-regulation to maintain physical activity and nutrition Major difference between the Basic and Enhanced conditions was the more general compared to the highly tailored goal setting, planning, and feedback self-regulation components. T: Social cognitive theory	Questionnaire TB: body weight T: digital bathroom scale C: PA-related social support, self-efficacy, outcome expectations, and self-regulation T: Health Beliefs Survey AT: baseline and 6-month post- and 16-month follow-up assessments	Both Basic and Enhanced interventions capable of promoting behavior change and target outcomes	

Health-Related Outcomes

Health-related outcomes included health-related quality of life (HRQOL) measures, modifiable risk factors for disease, psychological factors (depression, anxiety), stress, mood, and healthcare service utilization. Self-regulation-related outcomes were also measured in two of the 11 studies using survey methods (Janssen et al., 2012; Sniehotta et al., 2005). Self-management behaviors were measured in numerous studies. These self-management behaviors included altering modifiable risk factors, engaging in targeted health behaviors, either related to lifestyle changes in general of disease-specific, and control symptoms of disease.

Engagement in targeted health behaviors: **Lifestyle changes.** Seven of the 11 interventions measured an outcome related to engaging in a specific health behavior that participants were attempting to change (Dorough et al., 2014; Janssen et al., 2012; Lange et al., 2013; Marques et al., 2015; Sniehotta et al., 2005; Stadler et al., 2010; Winett et al., 2011). For interventions that did not focus on a particular disease, the goal-setting emphasis of the intervention was lifestyle changes. For these interventions, the targeted health behaviors measured were fruit and/or vegetable intake (Lange et al., 2013; Stadler et al., 2010; Winett et al., 2011), sodium restriction (Dorough et al., 2014), and physical activity (Dorough et al., 2014; Janssen et al., 2012; Marques et al., 2015; Sniehotta et al., 2005). Two interventions found no significant difference between self-regulation intervention and control groups in terms of dietary changes including sodium intake or fruit/vegetable consumption (Dorough et al.,2014; Janssen et al., 2012). Lange et al. (2013) did find a significant difference in fruit consumption for the intervention group. Janssen et al. (2012) did find significant differences in favor of the self-regulation intervention compared to control for the target behavior of physical activity measured in step counts. However, Sniehotta et al. (2005) did not find long-term maintenance of physical activity for the intervention group 4 months after discharge from the study. Looking across

studies it is evident that targeted health behaviors are inconsistently achieved and/or maintained from one intervention to the next when lifestyle modifications are the health behaviors of interest.

Engagement in targeted health behaviors: **Disease-specific.** Two of the 11 studies recruited participants currently managing a chronic condition such as asthma (Baptist et al., 2013) or end stage renal disease requiring hemodialysis therapy (Christensen et al. 2002). With regards to Baptist et al.'s participants with asthma, no difference was observed in lung function between intervention and control groups. In contrast, Christensen et al.'s intervention group hemodialysis participants displayed a pattern of decreased interdialytic weight (improved adherence) over time whereas control participants displayed a pattern of increased interdialytic weight (poorer adherence) over time.

Modifiable Risk Factors. Three of the 11 interventions measured outcomes related to common modifiable risk factors for chronic diseases such as hypertension, hyperlipidemia, and diabetes (Dorough et al., 2014; Janssen et al., 2012; Rameshbabu et al., 2018; Winett et al., 2011). These outcomes included resting blood pressure, weight, BMI, waist circumference, and fasting blood lipids. Dorough et al. (2014) found a larger decrease in systolic blood pressure and weight in the self-regulation intervention group than the control group. However, Janssen et al. (2012) and Winett et al. (2011) did not find significant risk factor differences between groups. Both of these studies included samples sizes upwards of 200 participants, although Dorough et al.'s sample size was comparatively small (N = 27).

Disease-related symptoms. Two of the 11 studies evaluated the effects of self-regulation interventions on symptoms, and both studies found that intervention groups reported improved symptom experiences (Baptist et al., 2013; Marques et al., 2005). Baptist et al.'s (2013) intervention group participants reported improved asthma symptoms compared to the

control group at 1, 6, and 12 months. Marques et al.'s (2005) participants were those meeting the CDC criteria for idiopathic chronic fatigue syndrome. Though the self-regulation intervention did not result in a significant increase in physical activity (targeted health behavior), the post-test results demonstrated a statistically significant reduction in subjective experiences of fatigue.

Self-Regulation Activities

Goal-setting. Consistent with the definition of self-regulation as being a process of goal-pursuit, all 11 studies included goal-setting as an early step in the interventions. Criteria for the health behavior goals mentioned by the articles reviewed included challenging and feasible (Stadler et al., 2010), specific (Marques et al., 2015), and salient (Janssen et al., 2012). Despite being ubiquitous across studies, the goal-setting step in each intervention assumed different labels and formats. Stadler et al. (2010) required participants to set a goal but referred to this action as writing down their "important wish" regarding their diet (p. 275). Marques et al. (2015) conducted a self-regulation intervention to increase physical activity among individuals diagnosed with chronic fatigue syndrome. This intervention asked participants to explore important health and life goals to which the physical activity goal could be related. In a similar manner, Janssen et al.'s (2012) intervention included an intake stage where cardiac rehabilitation participants described what constitutes meaningful recovery goals and how these goals were linked with the individual patient's higher-order life goals. Life goals tend to be the longer-term, more abstract aims such as "being healthy" or "being content." A consistent feature that did appear across all 11 of the studies with regards to goal-setting was that the goals were individually-tailored. However, as evidenced by the discussion above, the tailoring varied in terms of whether or not participants were encouraged to make a connection from their more concrete, 'do' goals (e.g., eat more whole-grain breads, walk three nights per week) back to their

higher-order ‘be’ goals (e.g., be healthy, be stronger).

Planning and self-monitoring. As goal-setting is the logical beginning point for self-regulation interventions, the finding from this review that intervention studies consistently started with this skill was unsurprising. Following goal-setting, eight of the 11 interventions emphasized planning, self-monitoring, or both, with planning manifesting in a variety of ways (Baptist et al., 2013; Dorough et al., 2014; Janssen et al., 2012; Lange et al., 2013; Lhakhang et al., 2015; Marques et al., 2015; Rameshbabu et al., 2018; Sniehotta et al., 2005; Stadler et al., 2010; Winett et al., 2011). Sniehotta et al. (2005) and Lhakhang et al. (2015) made the distinction between action and coping planning, referring to action planning as when, where, and how to act and coping planning as a person’s anticipation of future barriers and plans to overcome those barriers. Though uniformly named ‘coping planning’ across studies, of the 11 articles included in this review, four included a self-regulation skill that involved some type of contingency planning related to potential obstacles. Stadler et al. (2010) described having participants write down the most critical obstacle to their health behavior wish and then imagine when and where that obstacle might occur and what they could do to overcome, avoid, or even prevent the obstacle. Lange et al. (2013) had participants identify three potential obstacles and strategies to overcome them related to increasing fruit intake. Another version of planning appeared in Lange et al. (2013), and it consisted of preparatory behaviors related to the health behavior change of interest – the participants were trying to increase servings of fruit consumed and this preparatory behavior included buying and preparing fruit. Therefore, although planning was most commonly presented in these studies in terms of having participants formulate the ‘what,’ ‘when,’ ‘where,’ and ‘how’ of their intended health behaviors, almost half of the studies also included a planning stage dedicated to anticipating and developing plans to address potential barriers to change.

Self-monitoring was included in eight of the 11 self-regulation interventions (Baptist et al., 2013; Christensen et al., 2002; Dorough et al., 2014; Janssen et al., 2012; Marques et al., 2015; Rameshbabu et al., 2018; Sniehotta et al., 2005; Winett et al., 2011). Self-monitoring had a variety of target behaviors of interest, specific to each study sample, with tracking goal-related progress always being the focus. Interventions involving participants managing a chronic condition such as asthma, chronic fatigue syndrome, or end stage renal disease included self-monitoring skills pertaining to the disease activity for those conditions. Baptist et al.'s (2013) participants with asthma tracked asthma symptoms as well as lung function using peak flow meters. Christensen et al. (2002) taught end stage renal disease participants to track daily fluid intake related to the health behavior goal of reducing interdialytic weight gain (i.e., weight gain between hemodialysis treatments). Interventions that focused on the health behavior of increasing physical activity included pedometers as a means of tracking step counts (Dorough et al., 2014; Janssen et al., 2012; Marques et al., 2015; Winett et al., 2011). Christensen et al. (2002) and Sniehotta et al. (2005) included the use of written diaries, having participants record physiologic measurements as well as perceived progress towards health goals.

Feedback and self-evaluation. Goal-setting, planning, and self-monitoring are included in the majority of the self-regulation interventions. However, a greater degree of variability across studies is introduced in what remains of each intervention. Feedback was a component of the self-regulation intervention in three of the studies (Dorough et al., 2014; Janssen et al., 2012; Winett et al., 2011) and self-evaluation was included in three of the 11 interventions (Christensen et al., 2002; Janssen et al., 2012; Rameshbabu et al., 2018). Both Dorough et al. (2014) and Janssen et al. (2012) provided participants with individualized, progress-related feedback based on information supplied by participants, such as the previous week's fruit and vegetable consumption, home blood pressure readings, sodium intake, etc. The two interventions that

describe self-evaluation focus specifically on teaching positive self-evaluation (Christensen et al., 2002) and self-reward (Janssen et al., 2012) as a behavioral reinforcement strategy. Winett et al.'s (2011) study is unique in that it includes not only feedback but also mentions refining goals and plans based on feedback.

Preventing relapse, social support, and control. Only one of the 11 interventions included self-regulation activities focused on maintaining health behaviors once they were achieved (Marques et al., 2015). Step 4 of Marques et al.'s (2015) self-regulation intervention was termed "I am physically active now…and I want to keep it this way" and emphasized preventing relapse, including coping skills. Also, despite the fact that social support is included by Bandura (2005) as one of the widely-accepted features of self-regulation theories, only two of the 11 studies include social support as an aspect of their self-regulation interventions (Marques et al., 2015; Winett et al., 2011). Self-regulation implies enacting control in the pursuit of health goals (e.g., control impulses to seek immediate gratification in favor of less immediately rewarding health goals). However, despite this relationship only one intervention included a skill focused on control. Marques et al.'s (2015) intervention included teaching participants to control of distracting stimuli and negative emotions to maintain a focus on goal pursuit.

Analogous activities. Although some self-regulation interventions appear to diverge completely from the typical pattern of including goal-setting, planning, and self-monitoring, a closer examination reveals that these interventions may actually affix alternative labels to activities or categorize these three activities differently. Stadler et al.'s (2010) intervention focused on increasing fruit and vegetable consumption among women ages 30 to 50. The self-regulation activities included in this interventions are presented as mental contrasting and implementation intentions. Sniehotta et al. (2005) describes a self-regulation intervention used with cardiac rehabilitation patients that consists of action planning, coping planning, and action

control. Closer examination of these skills reveals that some overlap with or provide greater specificity in relation to activities previously discussed. For example, Sniehotta et al.'s (2005) action control is comprised of three elements including self-monitoring, awareness of standards, and self-regulatory effort. Stadler et al.'s mental contrasting can be characterized as identifying a goal and imagining the potential outcomes of achieving that goal. Implementation intentions involves imagining obstacles to achieving one's goals and how to overcome those obstacles – similar to Sniehotta et al.'s (2005) coping planning.

Quality

An overview of the quality of studies is displayed in Table 2. The most common limitation was a lack of blinding of the outcome assessment. Only three of the 11 studies provided a description of the blinding of outcomes assessment (Baptist el al., 2013; Lange et al., 2013; Winett et al., 2011). The second most common quality concern was the lack of statistical power analysis or low levels of power. Only four articles reported power analyses (Baptist el al., 2013; Christensen et al., 2002; Janssen et al., 2012; Marques et al., 2015), and one of these interventions was underpowered (Christensen et al., 2002). Lastly, although all 11 articles mentioned including theory-based interventions, the majority failed to adequately describe the theory from which the intervention was derived.

Table 2.

Quality Assessment Based on The Cochrane Collaboration's Risk of Bias Tool (Higgins & Green, 2011)

	Random sequence generation	Allocation concealment	Blinding of outcomes assessment	Incomplete outcome data	Selective reporting	Other bias
Baptist el al. (2013)	L	L	L	L	L	L
Christensen et al. (2002)	H	U	U	L	L	H
Dorough et al. (2014)	L	L	U	L	L	H
Janssen et al. (2012)	L	L	U	L	L	L
Lange et al. (2013)	U	L	L	L	L	L
Lhakhang et al (2015)	L	L	L	L	L	L
Marques et al. (2015)	L	H	U	L	L	H
Rameshbabu et al. (2018)	L	H	U	L	L	L
Sniehotta et al. (2005)	U	U	U	L	L	H
Stadler et al. (2010)	U	U	U	L	L	H
Winett et al. (2011)	U	L	L	L	L	L
Note. H = high risk of bias; L = low risk of bias; U = unclear risk of bias.						

Discussion

Across the 11 studies, successful health-related outcomes (e.g., self-management behaviors, changing modifiable risk factors) for intervention group participants were infrequently achieved (i.e., non-significant outcome findings when comparing intervention and control groups). For the two studies that considered disease-specific symptoms, participants did report improved symptom experience even if targeted health behaviors were not accomplished (e.g., increased physical activity in Marques et al.'s [2005] study of patients with chronic fatigue syndrome). These findings suggest that self-regulation research has perhaps not progressed to

the point where interventional research is appropriate. The wide variability in self-regulation activities that researchers choose to include in their interventions is yet another indication the self-regulation is still not well understood.

The majority of self-regulation interventions included components of goal-setting, planning, and self-monitoring of goal-related behaviors. Beyond these three components, great diversity was noted for the remaining self-regulation activities included in the 11 studies. Even for studies that cited the same theoretical basis, the interventions derived therefrom consisted of varying activities from the self-regulation process. For example, Lange et al. (2013) described their self-regulation intervention as being based on social cognitive theory, and the intervention included goal-setting, planning, and action control. Winett et al. (2011) also detailed a self-regulation intervention based on social cognitive theory that included goal-setting, planning, tracking, and feedback.

This variability suggests that there are inconsistencies in the interventions reviewed regarding what constitutes self-regulation and its theoretical underpinnings. Before researchers proceed with designing future self-regulation intervention studies, this systematic review has demonstrated that additional research is needed that assesses the process of self-regulation. Although all 11 studies provided measures of health-related outcomes, only two of the 11 studies included outcome measures that actually assessed participants' engagement in the self-regulation process (Janssen et al., 2012; Lange et al., 2013;). Therefore, even for studies that demonstrated participant health behavior change during the duration of the intervention, it remains questionable whether or not changes were related to actually engaging in self-regulation and which precise aspects of self-regulation (e.g., goal-setting, planning, tracking) were specifically responsible for behavior modification.

Future Research

Additional self-regulation research is needed that focuses on assessing whether or not and to what extend individuals actually engage in the self-regulation process. The variability in self-regulation theories applied to intervention studies reviewed and the variability in self-regulation components included in those interventions suggests that contemporary research in self-regulation needs to seek further clarity on individual engagement in the process before more interventions can be designed aimed at modifying how people self-regulate.

Limitations

A single author screened all of the article titles and abstractions and was responsible for reading the full text articles. The same individual also conducted the quality screening. Only English-language articles were reviewed; therefore, relevant articles may have been inadvertently missed. Descriptions of interventions were not always provided in the greatest detail, hence, there may have been additional self-regulation activities taught that were not delineated in this article due to insufficient descriptions in the articles reviewed.

Clinical Relevance

Nurses working as member of interdisciplinary healthcare teams have an important role in the development of self-regulation activities among patients. Ideally, in each encounter with a patient, nurses should take the opportunity to assess the self-regulation activities than a person successfully uses and to teach the activities that are lacking. Many of the health behaviors individuals are encouraged to adopt are not inherently enjoyable or simple, but it is incumbent upon nurses to help patients set health goals and empower them to purse those goals as a means of promoting health behavior modification and long-term maintenance.

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CHAPTER 3

Method

In this chapter the primary study is discussed to provide background regarding the intervention that informs the current study. The methods for the current study, including design, sample, procedures, data collection, variables, and plans for analysis are described. This secondary data analysis was conducted using EMA data collected from an NIH-funded osteoporosis prevention study.

Primary Study Overview

Striving to be Strong (STBS) was a three-group, longitudinal, randomized controlled trial that tested the efficacy of a theory-based, dynamically-tailored, self-management intervention (delivered in the form of a smartphone app) to facilitate health behavior change related to osteoporosis prevention (Ryan et al., 2018). The STBS study compared four osteoporosis prevention areas (calcium intake, physical activity, strength, and balance) across three study groups (intervention, wait-list control, and standard care arms) with data collected between April 2012 and May 2016. In addition to self-report tools (e.g., calcium intake diaries), bone mineral density screenings, and physical measures assessing balance, strength, and physical activity were completed during the course of the study. All participants completed EMAs electronically using a smartphone app. These study-generated EMAs were sent wirelessly by the primary study's file server. EMAs measured self-reported engagement in the four osteoporosis areas and self-regulation *at the time* the EMA was received by the participant. Participants were instructed to respond to the randomly sent EMAs delivered wirelessly to their study phones. In addition, participant could initiate EMAs on their own. Study-generated EMAs were text messages sent at random times during any 10-hour time span that the participant self-selected. This random schedule is considered better at achieving a representative sampling of participant activities

(Shiffman, 2009). The text messages prompted participants to log into a specific EMA app that was pre-loaded onto their smartphones and complete a 2-item EMA (these 2 items never changed throughout the course of the study). Participants received three reminders, 15 minutes apart, before the EMA expired. The study-generated EMAs were delivered to participants according to the schedule displayed in Table 2. Self-reported responses to EMAs were wirelessly transmitted and stored on a secure server as soon as they were answered by participants.

Table 2

EMA Delivery Schedule for First 12-Weeks in Study

Day in Study (Weeks)	Signal-Contingent EMAs	Potential study-initiated EMA prompts (Total = 196)
1-28 (weeks 1-4)	4/day	112
29-56 (weeks 5-8)	2/day	56
57-84 (weeks 9-12)	1/day	28

Participants in the intervention arm of the STBS study received an app that was based on the theoretical framework provided by the Individual and Family Self-Management Theory (IFSMT) (Ryan & Sawin, 2009). Each osteoporosis prevention area emphasized in the app (calcium intake, balance, strength, and physical activity) had parallel sub-sections including current, evidence-based information and recommendations regarding health behaviors that promoted bone health (e.g., calcium intake from diet advocated by the National Osteoporosis Foundation [NOF] for increasing bone deposition). Other sub-sections besides 'information' included: 'assessments' of current behaviors related to each of the four areas as well as assessments of confidence that participants could enact change; 'personalized feedback' in which participants could access graphs based on self-reported progress towards a self-set goal recorded

by the participant within the app; and 'self-regulation skills and abilities' where participants could set goals, make plans, document progress towards goals, and review goal progress. The app recorded the time participants spent in any particular section of the app, results of the assessments completed, and any self-regulation activities created or reviewed in the app (e.g., goals, plans, self-evaluations). Each app section contained a unique feature tailored to the particular prevention area. The calcium intake section included calcium logs where participants could enter and track their calcium consumption and review/search lists of calcium-rich foods. Strength and balance included videos of recommended exercises. Participants were encouraged by the research team to use the app for 20-30 minutes at a time, three to four times a week (Ryan et al., 2018). Table 3 provides examples of information and recommendations included in different app sections and samples of goals and plans set by participants as part of the 'self-regulation skills and abilities' sub-section. Participants could develop pre-formulated goals and plans by stringing elements together from the app categories 'what?', 'when?', 'where?', 'how?', or they could write entirely new goals and plans without the assistance of app-provided phrases.

Table 3

Osteoporosis Prevention Areas, Recommendations, and Sample Goals and Plans Provided by Intervention App

Prevention Area	Recommendations & Information	Sample Goals and Plans
Calcium Intake	- Obtain adequate amount of dietary calcium - Balanced diet including low-fat dairy products, fruits, and vegetables - Women age 51 and older and men age 71 and older should consume 1200 mg/day of calcium (IOM, 2011)	*Goal:* "My goal is to increase my calcium intake." *Plan:* "I will do this by adding a daily yogurt to my lunch. I will buy the yogurt on my way home from work and pack it in my work lunch bag the night before so I don't forget."
Strength	- Regular weight-bearing and muscle-strengthening exercise to reduce the risk of falls and fractures - Weight-bearing exercise involves bones and muscles work against gravity as the feet and legs bear the body's weight (e.g., walking, jogging, stair climbing, most athletic sports) - Muscle-strengthening exercise includes weight training and other resistive exercises, such as yoga, Pilates, and boot camp programs	*Goal:* "My goal is to be strong enough to do 25 push-ups." *Plan:* "Twice per day I will 5 push-ups for one week. Then I will increase the number of push-ups I do by intervals of 5 each week until I am doing 25 push-ups at a time without stopping. I will do the push-ups when I am getting ready for work in the morning and right away when I get home from work."
Balance	- Treating risk factors for falls including engagement in balance training	*Goal:* "My goal is to balance on one foot with my eyes closed for 60 seconds." *Plan:* "I will balance for as long as I can while I am waiting in line at the store, and I will do this at least twice per day."
Physical Activity	- Lifelong physical activity for osteoporosis prevention and overall health	*Goal:* "My goal is to be able to run for a longer amount of time without stopping." *Plan:* "When I exercise at my fitness center Mondays, Wednesdays, and Fridays after work, I will increase the amount of time I spend on the treadmill by 5 minutes until I reach the goal of 60 minutes on the treadmill three times per week."
* Cosman et al., 2014 - The Clinician's Guide to Prevention and Treatment of Osteoporosis, developed by an expert committee of the National Osteoporosis Foundation (NOF)		

Primary Study Sample

STBS participants included a convenience sample of 290 community-dwelling, healthy women who participated in the study for 1 year (intervention arm, $n = 95$; wait-list control arm, $n = 96$: standard care arm, $n = 99$). Participants were able to read and write in English, ages 40 to 60, with no prior history of osteoporosis. These women lived in Southeastern Wisconsin, Central Wisconsin, and Chicago, Illinois. Exclusion criteria were diagnosis of osteoporosis, unstable chronic conditions, less than 5 years post cancer treatment, taking medications impacting bone, pregnancy, or engaging in high intensity exercise more than 2 times per week for greater than 3 months.

Current Study Method

The design of the current study was a secondary analysis of the EMA data collected from the intervention arm participants during the first 12 weeks of the STBS study. EMA data from these participants was used to describe engagement in osteoporosis prevention (research question 1), self-regulation activities (research question 2), and self-management behaviors (research question 3). EMAs were delivered electronically to an app, designed for the primary study, and located on participants' study smartphones.

Current Study Sample

The sample for this analysis consisted of 95 participants from the intervention arm of the primary study who completed the first 12 weeks of EMAs. The sample characteristics are shown in Table 4. All participants were female, with the age range of 40 to 60 years of age. The average age of participants was 50.7 years old ($SD = 5.2$). The majority of the sample was married (72.6%) and identified as White (88.4%). The majority of the sample reported completing an undergraduate or graduate degree (77.9%).

Table 4

Description of Sample (N = 95)

Age groups (years)	Frequency (%)
40-44	15 (16%)
45-49	21 (22%)
50-54	32 (34%)
55-59	24 (25%)
60	3 (3%)
Marital Status	
Married	69 (73%)
Single	11 (10%)
Divorced	16 (17%)
Education status	
High School degree	4 (4%)
Some college or specialized training	17 (18%)
College or university degree	42 (44%)
Graduate degree and above	32 (34%)
Ethnicity	
Hispanic or Latina	2 (2%)
Non Hispanic	93 (98%)
Race	
Asian	4 (4%)
Black or African American	6 (6%)
Caucasian	84 (89%)
Chose not to respond	1 (1%)

Data Structure

A de-identified data set was provided to the researcher as an SPSS file, and the data included the EMAs collected during the first 12 weeks in study as part of the primary study.

EMA Variables. The primary variables for the current study were grouped according to three categories: 1) osteoporosis prevention areas (included four variables: calcium intake, physical activity, balance, and strength), 2) self-regulations activities (included seven variables: the self-regulation activities of goal-setting, planning, self-monitoring, decision-making, reflection, emotional control, self-evaluation), and 3) self-management behavior (the one outcome variable of the study). Frequencies and percentages of EMA responses (N = 13,310)

that affirmed participants' engagement in these 12 variables were used to answer research questions. The 12 variables are repeated measures completed in response to EMAs (smartphone prompted participants to complete).

Table 5

Data Analysis Plans for Current Study

Purpose. The purpose of the current study is to conduct an in-depth, descriptive analysis of the osteoporosis prevention areas and self-regulation activities reported by participants over a 3-month time period.					
Research Question	**Unit of Analysis**	**Variable**	**Tool**	**Level**	**Statistics**
RQ1. During the initiation phase of behavior change, are there differences in participants' reported engagement in osteoporosis prevention areas (calcium intake, strength, balance, and physical activity) in response to EMA sampling?	Participant	self-reported engagement in 4 osteoporosis prevention areas (calcium intake, balance, strength, and physical activity)	EMA (first question)	Nominal	Descriptive analysis of categorical variables conducted by examining frequencies and percentages for three time groupings: first 90 days in study, by months (first 3 months), by week (first 13 weeks)
RQ2. During the initiation phase of behavior change, are there differences in participants' reported use of self-regulation activities (e.g., goal-setting, planning, self-monitoring) in response to EMA sampling?	Participant	self-reported engagement in 7 possible theoretically-derived self-regulation activities (goal-setting, planning, decision-making self-monitoring, emotional control, reflection, self-evaluation)	EMA (second question)	Nominal	Descriptive analysis of categorical variables conducted by examining frequencies and percentages for three time groupings: first 90 days in study, by months (first 3 months), by week (first 13 weeks)
RQ3. During the initiation phase of behavior change, are there differences in participants' reported achievement of self-management behaviors (e.g., increasing calcium intake, balance, strength, or physical activity)?	Participant	self-reported engagement in theoretically-derived self-regulation activity serving as a proxy health behavior outcome in the present study (self-regulation activity of 'action')	EMA (second question)	Nominal	Descriptive analysis of categorical variables conducted by examining frequencies and percentages for three time groupings: first 90 days in study, by months (first 3 months), by week (first 13 weeks)

Each 2-item EMA consisted of two questions that both needed to be answered by the participant for the EMA data to be valid for analysis. Prior to completing each EMA, the participant had an opportunity to report that she had not engaged in any self-regulation activities related to any of the four osteoporosis prevention areas (e.g., there was a response option of "Skip this EMA because I have not done anything related to osteoporosis prevention since I last completed an EMA"). If the participant chose to complete the EMA, Question 1 asked participants to report which, if any, of the four osteoporosis prevention areas (calcium intake, physical activity, balance, and strength) they engaged in recently (specifically, the language of Question 1 asked participants to report which areas they had engaged in "since the last time they answered an EMA." The response to this question was coded as dichotomous for each osteoporosis prevention area (did not report doing something in that area = 0; reported doing something related to that area = 1). As a sample EMA response, if a participant selected "calcium intake" and "strength" in response to EMA Question 1, her response would be coded as: Strength=1, Balance=0, Physical Activity=0, and Calcium Intake=1. A woman had the option of selecting more than one area for any particular EMA Question 1.

Question 2 of the EMA asked participants about their engagement in each of the seven self-regulation activities (e.g., goal-setting, self-monitoring, planning, reflection, emotional control, self-evaluation, decision-making) and the one outcome variable (self-management behavior). Similar to Question 1, responses were coded as "0" or "1" for each of the eight self-regulation activities presented in Question 2. See "Sample EMA" in the Appendix A for screenshots of the EMA questions as they appear on participants' smartphones. Table 5 provides an outline of the analytic plan for each of the three research questions.

Protection of Human Subjects

The current study was approved by the University of Wisconsin – Milwaukee IRB (Appendix B). The student PI received a de-identified dataset. The dataset analyzed in the current study was in the form of electronic EMA responses answered via a smartphone app and stored on an external hard-drive stored in a locked file cabinet, in a locked room in Cunningham Hall at the University of Wisconsin – Milwaukee. The external hard-drive was not networked and was password protected.

Summary

The methods for both the primary study and the current study were described. The current study uses the first 12 weeks of the primary study's EMA data for secondary data analysis. The 12 study variables, derived from EMAs, are repeated measures and nominal level. The analytic plan involved using frequencies and percentages of variable responses to answer the three research questions.

In chapter 4 the results for Research Question 1 are presented – during the initiation phase of behavior change, are there differences in participants' reported engagement in osteoporosis prevention areas (calcium intake, strength, balance, and physical activity) in response to EMA sampling? Research Questions 2 and 3 are addressed in the second half of chapter 4, within the Results manuscript entitle: "Self-Regulation activities among women pursuing osteoporosis prevention."

CHAPTER 4

Results

The first part of this chapter presents results pertaining to preliminary EMA data analysis and Research Question 1, which focuses on participants' self-reported engagement in the four different osteoporosis prevention areas, according to EMAs completed during the first 12 weeks in study. These data are examined first for the entire 12 weeks, and then, to identify potential patterns or trends in data over time, data is compared monthly and weekly for each of the four osteoporosis prevention areas (four variables: calcium intake, balance, strength, physical activity). Following preliminary analysis of EMA data and Research Question 1 results, the remainder of the chapter consists of Manuscript 3, which presents the results to Research Questions 2 and 3. Research Questions 2 and 3 emphasized participants' reported engagement in the self-regulation progress (Question 2) and health behavior change outcomes (Question 3)

Preliminary Analysis

Before EMA data could be analyzed to answer the three research questions, data had to be checked for accuracy and consistency. The EMA data analyzed in the current study was included in a single SPSS data file that was limited to the first 12 weeks of study for the intervention group participants only. A baseline survey completed by all primary study participants entitled "All About You" was used to collect information regarding participant age, education, race, and ethnicity.

A preliminary examination of the data was conducted to determine if any variables needed to be transformed, recoded, or created to answer the three research questions. The number of EMAs completed by each participant on a daily basis was examined. During preliminary data review, it was apparent that participation was not consistent for each participant

(e.g., each participant did not complete the prescribed number of EMAs according to Table 2). The participants with the highest number of completed EMAs were examined first to determine the range of variability in EMA completion. EMA completion ranged from as few as 21 EMAs completed in the 12-week time period to as many as 377 EMAs completed by one participant during the same time period. In reviewing the Informed Consents participants signed, the consent language did not indicate that enrollment in the primary study would be jeopardized by answering fewer EMAs than participants received. In other words, there was no requirement to complete EMA nor were there consequences if participants did not complete the study-generated EMAs that they received randomly throughout the day.

Another, albeit lesser issue, since it did not impact the integrity of the data collected nor data analysis, was the fact that the EMA application allowed participants to select an osteoporosis prevention area (EMA Question 1) and leave the second question blank (EMA Question 2 assessed which self-regulation activity the participant engaged in pertaining to the area selected in Question 1). Preliminary data review indicated that participants could submit EMAs that were only half completed (i.e., only Question 1 was answered, but Question 2 was left blank). These incomplete EMAs (n = 212) were excluded from final analysis since the responses to Question 2 were blank, but the number of EMAs where this occurred was recorded as evidence of this circumstance, which appeared to be an error in the programming of the EMA.

Primary EMA Data Analysis

To answer Research Questions 1, 2, and 3, frequency tables where created for each of the 12 variables (four variables related to osteoporosis prevention area [EMA Question 1]; seven variables related to self-regulation activities [EMA Question 2]; one variable related to the health behavior outcome of action [EMA Question 2]). Tables included total frequency of individual

responses (i.e., for the entire 84 days [12 weeks]), responses by month (i.e., Months 1 through 3 with a single Month consisting of 28 days or 4 weeks), and responses by week (i.e., Weeks 1-12). Frequencies (from counted EMA responses for each possible response option) and percentages (the total number of EMAs completed as the denominator) were calculated for each of the research questions.

EMA Completion

A total of 13,310 EMAs were completed by 95 participants during the first 12 weeks of the primary study (18,620 EMAs sent; response rate of 71.5%).

Osteoporosis Prevention Areas – Research Question 1

RQ1: During the initiation phase of behavior change, are there differences in participants' reported engagement in osteoporosis prevention areas (calcium intake, strength, balance, and physical activity) in response to EMA sampling?

Table 6 shows the frequency and percentages of EMAs reported engagement in each of the fours osteoporosis prevention areas, as measured by the EMA question "Since the last time I answered these questions, I have done something related to one or more of the following activities (check all that apply)." The four potential responses were Calcium, Balance, Strength, and/or Physical Activity. The highest frequencies are shown in gray boxes.

Of the four osteoporosis prevention areas, participants reported focusing on Calcium most frequently (n = 7368; 55.4% of all EMAs) during the first 12 weeks in study. The next most frequently reported area was Physical Activity (n = 6038; 45.4% of all EMAs). Although the frequency with which participants reported doing something for their health related to Calcium was similar to that of Physical Activity, both Balance (n = 2914; 21.9%) and Strength (n = 2968; 22.3%) had the fewest number of EMA responses reported by participants.

To look for patterns in reported engagement in the four osteoporosis prevention areas, it was necessary to examine the data in a less aggregated manner and assess for differences by month and by week. For Calcium, Balance, Strength, and Physical Activity each area had similar response percentages within Months 1, 2, and 3. The highest percentage of EMAs was seen in Month 1, with Balance (56.8%) and Strength (55.4%) being being only slightly higher than Calcium (52%) and Physical Activity (51.4%) (Table 6). Therefore, for participants who answered EMA Question 1, approximately half of the EMA responses indicated participants had done something related to those four areas occurred in Month 1. Months 2 and 3 also reflected similar equity in percentage of EMAs corresponding across the four areas (Month 2 revealed approximately 30% of EMAs for each of the four areas and Month 3 was approximately 15% for each area). The gradual decline in EMA responses is partially explained by the gradual decline in the number of EMAs sent to participants as the study progressed. However, looking across areas for any particular month, participants were reporting similar levels of engagement for each of the four areas according to the percentage of their EMA response. As mentioned in the previous paragraph, when examining the EMA frequencies, it is apparent that participants reported engaging more in Calcium (7,368 EMAs) and Physical Activity (6,038 EMAs) than in Balance (2,914 EMAs) and Strength (2,968 EMAs).

Figure 2 shows EMA responses for each osteoporosis prevention area by week in study. Examining the week-by-week data allows for determination of any trends in EMA reporting for these four areas. Balance and Strength have almost identical trend lines. Plotted as a gradually declining slope. Calcium and Physical Activity have a more extreme slope lines, demonstrating more rapid declines in EMA responses for these two areas as the study progressed. A pattern emerges when looking at the EMAs responses in time blocks of 4 weeks, which corresponds to

the transitions in EMA sampling schedules. For each of the four areas, Weeks 1 though 4 and 9 through 12 reveal relatively flat or consistent EMA response frequencies. For Weeks 5 through 8, the line plotting EMA responses decreases more rapidly suggesting that this is a critical period when participants were reporting a decline in osteoporosis prevention engagement.

Table 6

Research Question 1: EMA Frequencies by Month for Self-Reported Engagement in Osteoporosis Prevention Areas (EMA N = 13,310)

Osteoporosis Prevention Area	Month 1	Month 2	Month 3	Total (12 Weeks; 13,310 EMA)
Calcium	3831 (52.0%)	2330 (31.6%)	1207 (16.4%)	7368 (55.4% of all EMAs)
Balance	1654 (56.8%)	853 (29.3%)	407 (14.0%)	2914 (21.9% of all EMAs)
Strength	1644 (55.4%)	867 (29.2%)	457 (15.4%)	2968 (22.3% of all EMAs)
Physical Activity	3106 (51.4%)	1899 (31.5%)	1033 (17.1%)	6038 (45.4% of all EMAs)

Gray boxes indicate the highest frequencies of EMA response

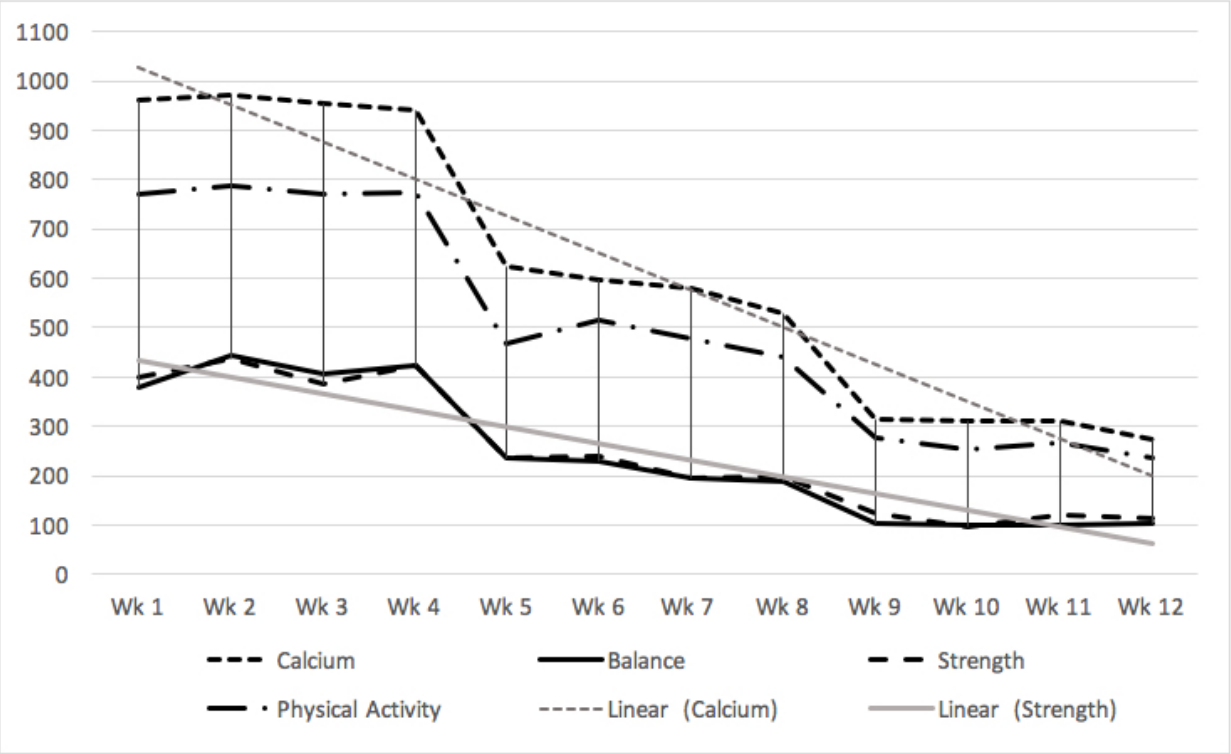

Figure 2. Research question 1: EMA frequencies by week for self-reported engagement in osteoporosis prevention areas (EMA N = 13,310)

Summary

Examining participants EMA responses to Question 1 reveals that Calcium is consistently the most frequently reported osteoporosis prevention area across the entire 12 weeks, followed by Physical Activity, although the differences in the frequencies become progressively less from Months 1 to 2 and Months 2 to 3 (see Figure 2). Strength and Balance, which are both less frequently reported by participants throughout the 12 weeks, have almost overlapping trend lines, suggesting consistently low reporting for each of these areas, even at the very beginning of the study. Calcium and physical activity display a more dramatic decline from Week 1 to Week 12. However, by the last 4 weeks of the study period under examination (i.e., Month 3), all four

osteoporosis prevention areas are being reported with similar frequencies (e.g., trend lines are closer to one another for all four areas than for Months 1 or 2).

Manuscript 3

Examination of Research Question 1 provided insight into which specific osteoporosis prevention areas garnered more focus from participants: Calcium intake, followed by, Physical Activity. The pattern of focus remained consistent throughout the first 12 weeks in study – Calcium intake and Physical Activity were more frequently reported than Balance and Strength throughout this time period. In addressing Research Questions 2 and 3, Manuscript 3 focuses on participants' responses to EMA Question 2 which queries participants regarding their engagement in seven self-regulation activities and the one outcome variable of self-management behaviors.

Manuscript 3 will be submitted to the peer-reviewed journal *American Journal of Health Promotion* for consideration. The manuscript is written according to the author guidelines provided on the journal's submission website. It is written according to the Publication Manual of the American Psychological Association (APA) Sixth Edition (2010) reference and citation requirements. The scope of the journal includes publishing studies that advance the science of health behavior change.

Manuscript 3

Title: Self-Regulation Activities Among Women Pursuing Osteoporosis Prevention Behaviors

Abstract

Self-regulation is a process that includes activities people engage in to achieve a goal. Poor self-regulation (i.e., inability to set specific, achievable goals; impaired planning skills) may contribute to unhealthy behaviors. Self-regulation as a concept is inconsistently applied and poorly understood. The purpose of this secondary analysis of Ecological Momentary Assessment (EMA) data was to develop an in-depth description of self-regulation, as conceptualized in Ryan's Integrated Theory of Health Behavior Change (2009), during the first 12 weeks of a behavior change intervention promoting osteoporosis prevention. Participants were 95 healthy women, ages 40 to 60, with no previous diagnosis of osteoporosis, who received a theory-based, individually-tailored intervention delivered via a smartphone app promoting health behavior change in four areas: calcium intake, physical activity, strength, and balance. The data came from two-item EMAs that participants received at random times throughout the day during the initiation of health behavior change (i.e., first 12 weeks in study). These EMAs provided real-time, ecologically valid measurements of participants self-reported engagement in self-regulation activities relative to one or more osteoporosis prevention area (calcium intake, physical activity, balance, strength). Ninety-five women completed 13,310 EMAs during the first 12 weeks in study. Goal-setting, planning, and action were the most frequently reported self regulation activities across all four prevention areas. The self-regulation activity of tracking was reported at higher frequencies for calcium and physical activity than for balance or strength. For balance and strength, participants were more likely to report engaging in the self-regulation activity of self-evaluation. Findings suggest that participants do not equally

utilize multiple, self-regulation activities and that theoretical assumptions of how people pursue change do not coincide with their real-world use of the behavior change process. Future research would consider evaluating self-regulation activities among different populations with different health risks and conditions. Policy and practice should consider piloting programs that include, at minimum, goal-setting, planning, and action as pivotal to any health behavior change skillset presented to patients or the public.

Purpose

In a national environment of escalating healthcare costs and use, changing individual behaviors and sustaining those changes is becoming foundational to improving health and keeping individuals living well at home and in their communities. By the middle of the 20th century, large-scale studies such as the Framingham Heart Study and the Seven Countries Study identified a major contributing factor to chronic diseases – individual decisions regarding health behaviors (Foody, Mendys, Liu, & Simpson, 2010). These studies elucidated the contributions of cigarette smoking, diet, and physical inactivity to the leading causes of death (Foody et al., 2010). Heart disease, stroke, cancer, type 2 diabetes, obesity, and arthritis are among the most common, costly, and preventable of all health problems (Ward, Schiller, & Goodman, 2014). These illnesses not only have a negative impact on quality of life, but they are costly in other ways. Bloom et al. (2011) estimated that non-communicable diseases result in economic losses for developing economies equivalent to 4 percent or 5 percent of their GDP per annum.

Domestic and international policies espouse the significance of improving public health (e.g. *Healthy People* reports from the Office of Disease Prevention and Health Promotion). These policies propose changes to a wide variety of behaviors, including diet and physical activity, tobacco and substance use, and adherence to treatment and screening guidelines. Effectively meeting these national and international health standards hinges on intervention strategies that effectively and efficiently alter people's behaviors (Rothman et al. 2015). However, when faced with the challenge of pursuing these mandates, healthcare professionals and health behavior scientists are at a loss given the limited theoretical and empirical guidance about which intervention strategies to use to change specific behavior (Sheeran, Klein, & Rothman, 2017).

Despite the known consequences of poor health behavior choices and the relative lack of guidance regarding which interventions strategies are most effective, the public remains fixated on the idea of changing health behaviors. Haberman, Brauer, Dwyer, and Edwards (2014) conducted a descriptive study that surveyed 111,449 individuals, asking them if they had made any health behavior changes in the previous 12 months. Fifty-eight percent of respondents reported making a health behavior change (29% reported increased exercise, 10% improved diet, 7% weight loss). Although individuals report achieving health behavior outcomes (increasing exercise, improving diet, etc.), health behavior change researchers and healthcare professionals are uncertain as to how change is initiated and maintained. Using theoretical models to explain people's actions has not lead to a clearer understanding thus far. Jones, Smith, and Llewellyn (2014) conducted a systematic review of interventional studies using the Health Belief Model (HBM), a theory used to design health behavior change interventions for over four decades. Of the 18 studies reviewed, 78% reported improvements in health behavior adherence. These results suggest that theory-driven interventions do understand and harness people's patterns of health behavior change activity. However, of the 18 studies reviewed, only six used the HBM in its entirety and only five measured health beliefs as outcomes. This review revealed that health behavior change success achieved by participants appeared to be somewhat unrelated to HBM constructs, which challenges the usefulness of this model as a theoretical basis for designing health behavior change interventions. This pattern is repeated throughout the literature, which is populated by overlapping theory-driven interventions showing modest efficacy in directing health behavior change with ambiguous connections between which theoretical and interventional components actually affected that change.

A possible reason for the modest efficacy of theory-driven, health behavior change interventions could be that these programs minimize the role of a basic mechanism of health behavior change, specifically self-regulation, a process that largely determines whether or not the behaviors promoted by interventions are adopted by individuals. However, before interventional studies, clinicians, or policymakers can hope to successfully incorporate the self-regulation process into programs and policies, a description of how people actually use self-regulation is a necessary initial step and the aim of the present study

The purpose of the secondary analysis study presented in this article was to utilize data collected from an interventional study that included community-dwelling, healthy women actively pursuing health behavior change to provide an in-depth description of the self-regulation process, as described in Ryan's Integrated Theory of Health Behavior Change (2009). The two research questions addressed in this article are:

- Research Question 1: During the initiation phase of behavior change, are there differences in participants' reported use of self-regulation activities (e.g., goal-setting, planning, self-monitoring) in response to EMA sampling?
- Research Question 2: During the initiation phase of behavior change, are there differences in participants' reported achievement of self-management behaviors (e.g., increasing calcium intake, balance, strength, or physical activity)

The initiation phase of behavior change, for the purposes of this study, refers to the first 12 weeks of after a health behavior change is undertaken. The intention of conducting such a descriptive study is to provide foundational understanding of how individuals actually pursue health behavior change – this is an undertaking that many researchers and clinicians have sidestepped in their design of health behavior change interventions and policies.

Methods

Design

The present study is a secondary analysis of Ecological Momentary Assessment (EMA) data collected during the first 12 weeks of a year-long intervention study. A detailed description of the intervention study, *Striving to Be Strong*, is presented elsewhere (Ryan et al., 2018). Briefly, the aim of the primary study was to test the efficacy of a theory-driven, individually-tailored intervention intended to promote initiation and maintenance of osteoporosis self-management in four target osteoporosis prevention areas (calcium intake from diet, strength, balance, and physical activity).

Sample

The sample for this analysis consisted of the 95 participants in the intervention group who completed 12 weeks of EMAs. Participants were able to read and write in English, ages 40 to 60, with no prior history of osteoporosis. These women lived in Southeastern Wisconsin, Central Wisconsin, and Chicago, Illinois. Exclusion criteria were diagnosis of osteoporosis, unstable chronic conditions, less than 5 years post cancer treatment, taking medications impacting bone, pregnancy, or engaging in high intensity exercise more than 2 times per week for greater than 3 months.

The sample characteristics of the interventions group for the current study are shown in Table 4. All participants were female, with the age range of 40 to 60 years of age. The average age of participants was 50.7 years old (SD = 5.2). The majority of the sample was married (72.6%) and identified as White (88.4%). The majority of the sample reported completing an undergraduate or graduate degree (77.9%).

Table 1

Description of Sample (N = 95)

Age groups (years)	Frequency (%)
40-44	15 (16%)
45-49	21 (22%)
50-54	32 (34%)
55-59	24 (25%)
60	3 (3%)
Marital Status	
Married	69 (73%)
Single	11 (10%)
Divorced	16 (17%)
Education status	
High School degree	4 (4%)
Some college or specialized training	17 (18%)
College or university degree	42 (44%)
Graduate degree and above	32 (34%)
Ethnicity	
Hispanic or Latina	2 (2%)
Non Hispanic	93 (98%)
Race	
Asian	4 (4%)
Black or African American	6 (6%)
Caucasian	84 (89%)
Chose not to respond	1 (1%)

Measurement Strategy

EMAs were self-reported measurements of four osteoporosis prevention areas, seven self-regulation activities, and one self-management behavior. They were administered repeatedly and designed to capture real-time data in an unobtrusive manner while participants were carrying out their daily routines in their typical environments (e.g., work, home, school, etc.) (Morren, Dulmen, van Ouwerkerk, & Bensing, 2009). EMAs took the form of a few, simple questions that participants answered quickly. In contemporary research, EMAs are

measured frequently throughout the day (ranging from 1 to 15 questions per day) for a study duration ranging from 1 day to 8 weeks (Stone et al., 1998). This method of data collection has been used via handheld PDAs (personal digital assistant) and smartphone devices. EMA measurement tools possess other advantageous characteristics such as minimizing recall bias in participants, improving ecological validity, and increasing the precision of the assessment data obtained. EMAs are the ideal modality in which to rapidly assess real-time behavior changes as they are being carried out by participants.

Previous research has concentrated on using EMAs to collect physiological data (e.g., blood pressure, heart rate), report symptomology (e.g., rate pain on a 0 to 10 pain scale), or indicate discrete events associated with a variety of treatment programs or conditions such as relapse among alcoholics, drug use among narcotics abusers, binge-eating episodes among those suffering from bulimia nervosa (Anestis et al., 2010; Morren et al., 2009; Poulin et al., 2010; Runyan et al., 2013). To date, EMAs have not been applied to the examination of health behavior processes such as self-regulation, nor have they been applied to capture responses to disease prevention interventions.

Data Set

During the first 12 weeks of participation in STBS, participants randomly received EMAs delivered via smartphones issued to each participant at the beginning of the study. These EMAs were text messages sent at random times during any 10-hour time span that the participant self-selected. This random schedule is considered better at achieving a representative sampling of participant activities (Shiffman, 2009). The text messages prompted participants to log into a specific EMA app that was pre-loaded onto their smartphones and complete an EMA, which consisted of the same two questions each time the participant was texted. Participants received

three reminders, 15 minutes apart, before the EMA expired. In addition to these study-generated EMAs, the participant could complete EMAs without study prompting, at any time during the course of the study. Participants were instructed to complete an EMA any time they engaged in a self-regulation activity for one or more of the four osteoporosis prevention areas. For the the first three months of the study, study-generated EMAs were delivered to participants according to the schedule displayed in Table 2. Self-reported responses to EMAs were wirelessly transmitted and stored on a secure server as soon as they were answered by participants.

Table 2

EMA Delivery Schedule for First 12-Weeks in Study

Day in Study (Weeks)	Signal-Contingent EMAs	Potential study-initiated EMA prompts (Total = 196)
1-28 (weeks 1-4)	4/day	112
29-56 (weeks 5-8)	2/day	56
57-84 (weeks 9-12)	1/day	28

Data Structure

A de-identified data set was provided to the researcher as an SPSS file. The data included the EMAs collected during the first 12 weeks in study as part of the primary study.

EMA Variables. The variables for the current study are grouped according to three categories: 1) osteoporosis prevention areas (included four variables: calcium intake, physical activity, balance, and strength), 2) self-regulations activities (included seven variables: the self-regulation activities of goal-setting, planning, self-monitoring, decision-making, reflection, emotional control, self-evaluation), and 3) self-management behavior (the one outcome variable

of the study). Frequencies and percentages of EMA responses (N = 13,310) that affirmed participants' engagement in these 12 variables were used to answer research questions. The 12 variables were repeated measures completed in response to EMAs (smartphone prompted participants to complete). Participants did have the opportunity, upon receiving an EMA, to report that they did not engage in any health behavior change activities (essentially to record that they saw the EMA, but did not have anything to report). However, this researcher did not have access to the EMAs where participants reported "no activity" related to the osteoporosis prevention areas, self-regulation activities, and self-management behaviors.

Each 2-item EMA consisted of two questions that both needed to be answered by the participant for the EMA data to be valid for analysis. The focus of this article is participant responses to EMA Question 2, which asked participants to report which, if any, of the eight self-regulation activities (e.g., goal-setting, self-monitoring, planning, reflection, emotional control, self-evaluation, decision-making, action). Responses were coded as "0" or "1" for each of the eight self-regulation activities presented in EMA Question 2. See "Sample EMA" in the Appendix A for screenshots of the EMA questions as they appear on participants' smartphones.

Results

Research Question 1: Self-Regulation Activities

A total of 13,310 EMAs were completed during the first 12 weeks of study. Examining the Self-Regulation (SR) Activities reported by participants began with an assessment of the total self-reported SR Activities for the entire 12-week period, followed by a consideration of monthly data (see Table 3 – light gray boxes are highest frequencies for monthly data, and dark gray boxes are highest frequencies for entire 12 weeks). The most frequently reported SR Activities were in the osteoporosis prevention areas of Calcium and Physical activity. For Calcium, having

specific goals (*n* = 1982; 14.9% of all EMAs), having specific plans (*n* = 1904; 14.3%), and self-monitoring (*n* = 1535; 11.5%) were the most frequently reported SR Activities for the first 12 weeks of study. In a similar pattern to Calcium, having specific goals (*n* = 1496; 11.2% of all EMAs), having specific plans (*n* = 1570; 11.8%), and self-monitoring related to Physical Activity (*n* = 1230; 9.2%) were the next most frequently reported SR Activities. Although reported less frequently than for Calcium and Physical Activity, examining Strength and Balance, participants reported engaging in similar patterns of SR Activities for those two osteoporosis prevention areas as well. For Strength, goal-setting (*n* = 945; 7.1%) and planning (*n* = 933; 7.0%) were reported more frequently that any other Strength-related SR Activity for the first 12 weeks of the study, and the same was true for Balance (goal-setting: *n* = 995; 7.5%; planning *n* = 882; 6.6%). For both Strength and Balance, the SR Activity of self-evaluation (i.e., "I really wanted to meet my goal, but I took care of other things instead") was more frequently reported than self-monitoring, a departure from results for Calcium and Physical Activity.

Table 3

Research Question 2: Self-Regulation Activities by Month and Total for 12 Weeks (EMA N = 13,310)

Calcium:

Self-Regulation Activity (by Osteoporosis Prevention Area)	Month 1	Month 2	Month 3	Total (12 weeks)
"I had a specific goal" (*goal-setting*)	1048 (7.9%)	630 (4.7%)	304 (2.3%)	1982 (14.9%)
"I had specific plans" (*planning*)	977 (7.3%)	602 (4.5%)	325 (2.4%)	1904 (14.3%)
"I tracked what I did" (*self-monitoring*)	872 (6.6%)	450 (3.4%)	213 (1.6.%)	1535 (11.5%)
"I thought about the reasons why my plans did or did not work" (*reflection*)	244 (1.8%)	149 (1.1%)	65 (0.5%)	458 (3.4%)
"I made a decision to modify or change my goal" (*decision-making*)	259 (1.9%)	76 (0.6%)	38 (0.3%)	373 (2.8%)
"My feelings affected my ability" (*emotional control*)	227 (1.7%)	127 (1.0%)	62 (0.5%)	416 (3.1%)
"I really wanted to meet my goal, but I took care of other things instead" (*self-evaluation*)	400 (3.0%)	161 (1.2%)	89 (0.7%)	650 (4.9%)

Table 3 Continued

Balance:				
Self-Regulation Activity (by Osteoporosis Prevention Area)	Month 1	Month 2	Month 3	Total (12 weeks)
"I had a specific goal" (*goal-setting*)	538 (4.0%)	313 (2.4%)	144 (1.1%)	995 (7.5%)
"I had specific plans" (*planning*)	480 (3.6%)	260 (2.0%)	142 (1.1%)	882 (6.6%)
"I tracked what I did" (*self-monitoring*)	344 (2.6%)	124 (0.9%)	83 (0.6%)	551 (4.1%)
"I thought about the reasons why my plans did or did not work" (*reflection*)	155 (1.2%)	116 (0.9%)	64 (0.5%)	335 (2.5%)
"I made a decision to modify or change my goal" (*decision-making*)	219 (1.6%)	77 (0.6%)	31 (0.2%)	327 (2.5%)
"My feelings affected my ability" (*emotional control*)	129 (1.0%)	87 (0.7%)	48 (0.4%)	264 (2.0%)
"I really wanted to meet my goal, but I took care of other things instead" (*self-evaluation*)	445 (3.3%)	212 (1.6%)	120 (0.9%)	777 (5.8%)
Strength:				
Self-Regulation Activity (by Osteoporosis Prevention Area)	Month 1	Month 2	Month 3	Total (12 weeks)
"I had a specific goal" (*goal-setting*)	504 (3.8%)	284 (2.1%)	157 (1.2%)	945 (7.1%)
"I had specific plans" (*planning*)	484 (3.6%)	280 (2.1%)	169 (1.3%)	933 (7.0%)
"I tracked what I did" (*self-monitoring*)	365 (2.7%)	116 (0.9%)	90 (0.7%)	571 (4.3%)
"I thought about the reasons why my plans did or did not work" (*reflection*)	165 (1.2%)	119 (0.9%)	54 (0.4%)	338 (2.5%)
"I made a decision to modify or change my goal" (*decision-making*)	219 (1.6%)	82 (0.6%)	38 (0.3%)	339 (2.5%)
"My feelings affected my ability" (*emotional control*)	131 (1.0%)	111 (0.8%)	68 (0.5%)	310 (2.3%)
"I really wanted to meet my goal, but I took care of other things instead" (*self-evaluation*)	368 (2.8%)	192 (1.4%)	114 (0.9%)	674 (5.1%)
Physical Activity:				
Self-Regulation Activity (by Osteoporosis Prevention Area)	Month 1	Month 2	Month 3	Total (12 weeks)
"I had a specific goal" (*goal-setting*)	739 (5.6%)	505 (3.8%)	252 (1.9%)	1496 (11.2%)
"I had specific plans" (*planning*)	771 (5.8%)	525 (3.9%)	274 (2.1%)	1570 (11.8%)
"I tracked what I did" (*self-monitoring*)	677 (5.1%)	364 (2.7%)	189 (1.4%)	1230 (9.2%)
"I thought about the reasons why my plans did or did not work" (*reflection*)	204 (1.5%)	163 (1.2%)	72 (0.5%)	439 (3.2%)
"I made a decision to modify or change my goal" (*decision-making*)	297 (2.2%)	94 (0.7%)	42 (0.3%)	433 (3.3%)
"My feelings affected my ability" (*emotional control*)	259 (1.9%)	145 (1.1%)	89 (0.7%)	493 (3.7%)
"I really wanted to meet my goal, but I took care of other things instead" (*self-evaluation*)	608 (4.6%)	329 (2.5%)	150 (1.1%)	1087 (8.2%)

* italicized term is the Self-Regulation Activity that each EMA response option corresponds to

Gray boxes indicate the highest frequencies of EMA response

To ascertain if there were patterns in SR Activities for the four osteoporosis prevention areas, the percentage of EMA responses 'yes' for each particular SR Activity were plotted according to week in study for the first 12 weeks. The results for each osteoporosis prevention area are depicted by the graphs in Figure 1.

SR Activities reported most frequently, relative to one another, examined on a weekly basis, were having a specific goal and planning. This held true for all four osteoporosis prevention areas. For each graph represented in Figure 1, these SR Activities are the uppermost lines, indicating they were the SR Activities consistently reported at the highest percentages throughout each week for the first 12 weeks. For Calcium and Physical Activity, the percentages of EMA reporting having a goal and planning were closely aligned from Weeks 1 thought 12 – both SR Activities saw an increase in reported EMAs, relative to the other SR Activities, from Week 1 to Week 2, followed by a sharp decline in Week 3 with a gradual recovery over subsequent weeks. At Week 8, for both Calcium and Physical Activity, another decline occurred and continued through the end of the 12 weeks. After having a goal and planning, the next highest percentage of EMAs, for Calcium and Physical Activity, were reported for the SR Activity tracking; however, these percentages started declining in Week 2, with the most rapid decline occurring between Weeks 2 and 3. There occurred a slight recovery in percentages for tracking at Weeks 5 and 8, but this increase never returned to the highest percentages seen in Week 1. For Calcium and Physical Activity, SR Activities that had consistently low percentages were making a decision to modify or change a goal (decision-making), feelings affecting abilities (emotional control), thinking about reasons why plans worked or not (reflection). A difference between the two graphs is seen for the SR Activity 'wanting to meet a goal but taking care of other things instead' (self-evaluation). For Physical Activity, this SR Activity self-evaluation

followed the trend line for tracking and started in the 17 to 20% range for Weeks 1 and 2, respectively. Self-evaluation gradually declined over the course of the following 10 weeks and decreased to 10% by Week 12. For Calcium, self-evaluation remained at a consistently lower percentage throughout the 12 weeks, following the same trend lines as seen for decision-making, emotional control, and reflection.

As with Calcium and Physical activity, Strength and Balance had consistently higher percentages of SR Activities reported for having a goal and planning. Unlike Calcium and Physical Activity, self-monitoring for Strength and Balance was less commonly reported, starting as a high percentage in Weeks 1 and 2, and gradually declining for Weeks 3 through 6 (Strength) and 3 through 9 (Balance), and then beginning a gradual increase in percentage through the remainder of the 12 Weeks. Percentages of the SR Activity self-evaluation were more consistently high for Strength and Balance as compared to Calcium and Physical Activity across the 12 weeks.

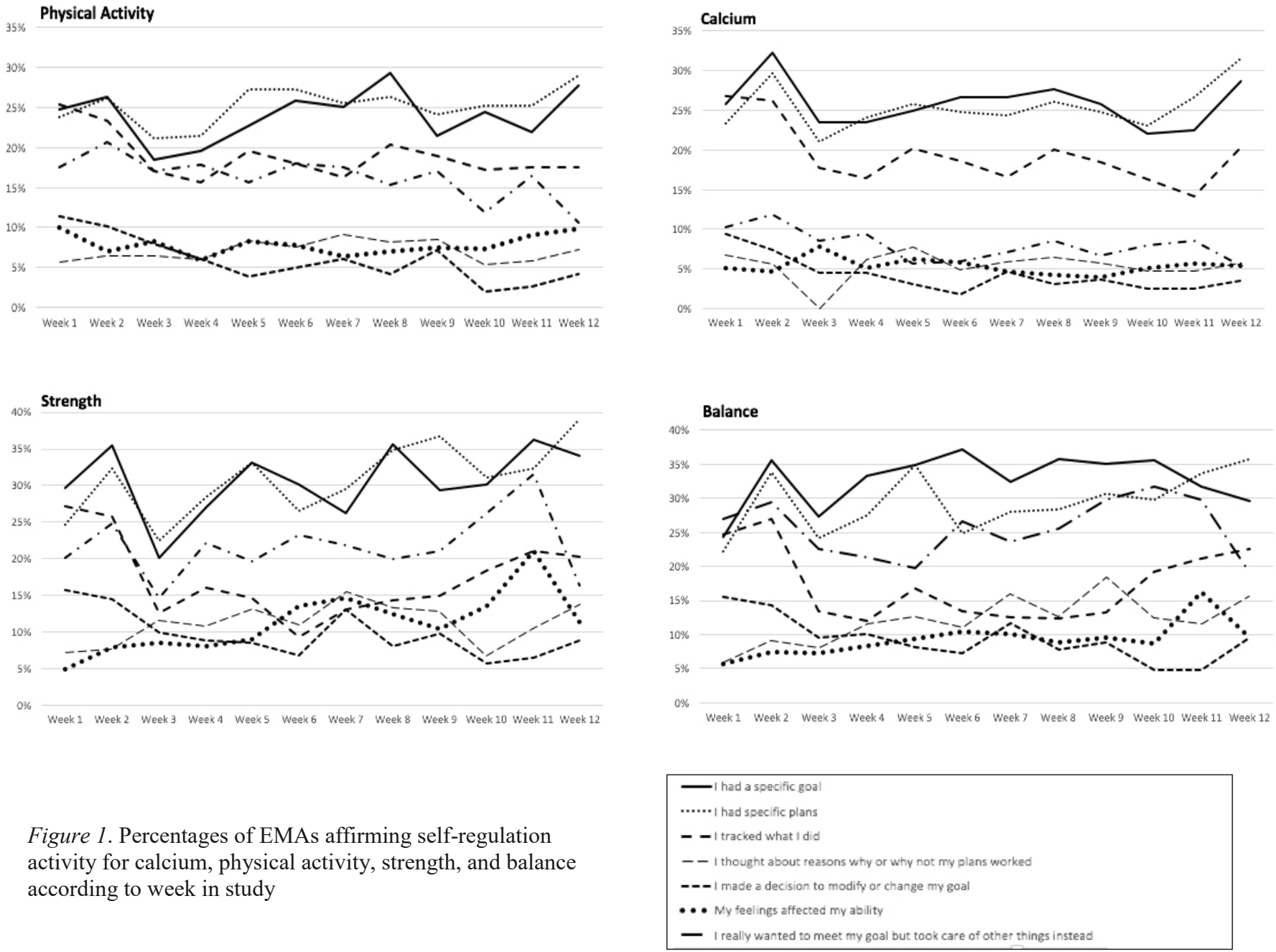

Figure 1. Percentages of EMAs affirming self-regulation activity for calcium, physical activity, strength, and balance according to week in study

Research Question 2: Self-Regulation Outcomes

To assess whether or not participants reported achieving a self-management behavior outcome, this researcher examined the number of EMAs where participants answered affirmatively to the statement: "I did something to increase my…" This response option was intended to measure a self-management behavior outcome by indicating, via self-report, that the participant took some action to change a health behavior. Reported engagement in 'action' serves as a proxy for achieving desired health behavior change outcomes (i.e., actually doing something to move towards changing a target health behavior).

Participants reported doing something to increase their Calcium intake more frequently than any of the other three osteoporosis prevention areas for the entire 12-week time period (n = 5895; 44.3% of all EMAs), followed by doing something to increase Physical Activity (n = 4097; 30.8% of all EMAs). Both Strength (n = 1767; 13.3% of all EMAs) and Balance (n = 1647; 12.4% of all EMAs) were similar in the number of reported EMAs (Table 4). A similar trend is seen when examining the EMA frequencies month by month. For Months 1, 2, and 3 the frequency for reporting the SR Activity 'action' was always highest for Calcium, followed by Physical Activity. Balance and Strength were closely aligned in frequency of EMA responses.

Table 4

Research Question 3: Self-Reported Achievement of Health Behavior Change Outcomes (EMA *N* = 13,310)

Self-Regulation Activity (by Osteoporosis Prevention Area)	Month 1	Month 2	Month 3	Total (12 weeks)
"I did something to increase my calcium intake" (*action*)	2969 (22.3%)	1909 (14.3%)	1017 (7.6%)	5895 (44.3%)
"I did something to increase my balance" (*action*)	921 (6.7%)	491 (3.7%)	235 (1.8%)	1647 (12.4%)
"I did something to increase my strength" (*action*)	974 (7.3%)	517 (3.9%)	276 (2.1%)	1767 (13.3%)
"I did something to increase my physical activity" (*action*)	2005 (15.1%)	1295 (9.7%)	797 (6.0%)	4097 (30.8%)

EMA data for the SR Activity of action was also examined on a weekly basis for each of the four osteoporosis prevention areas. Examining weekly EMA data, Calcium held the highest percentage of EMAs reported with the trend line gradually increasing during the 12 weeks, with minor instances of percentage declines and recoveries. Physical Activity demonstrated a steeper increase beginning in Week 3 through Week 10. Balance and Strength percentages, were very closely aligned, with the weekly trend lines overlapping one another.

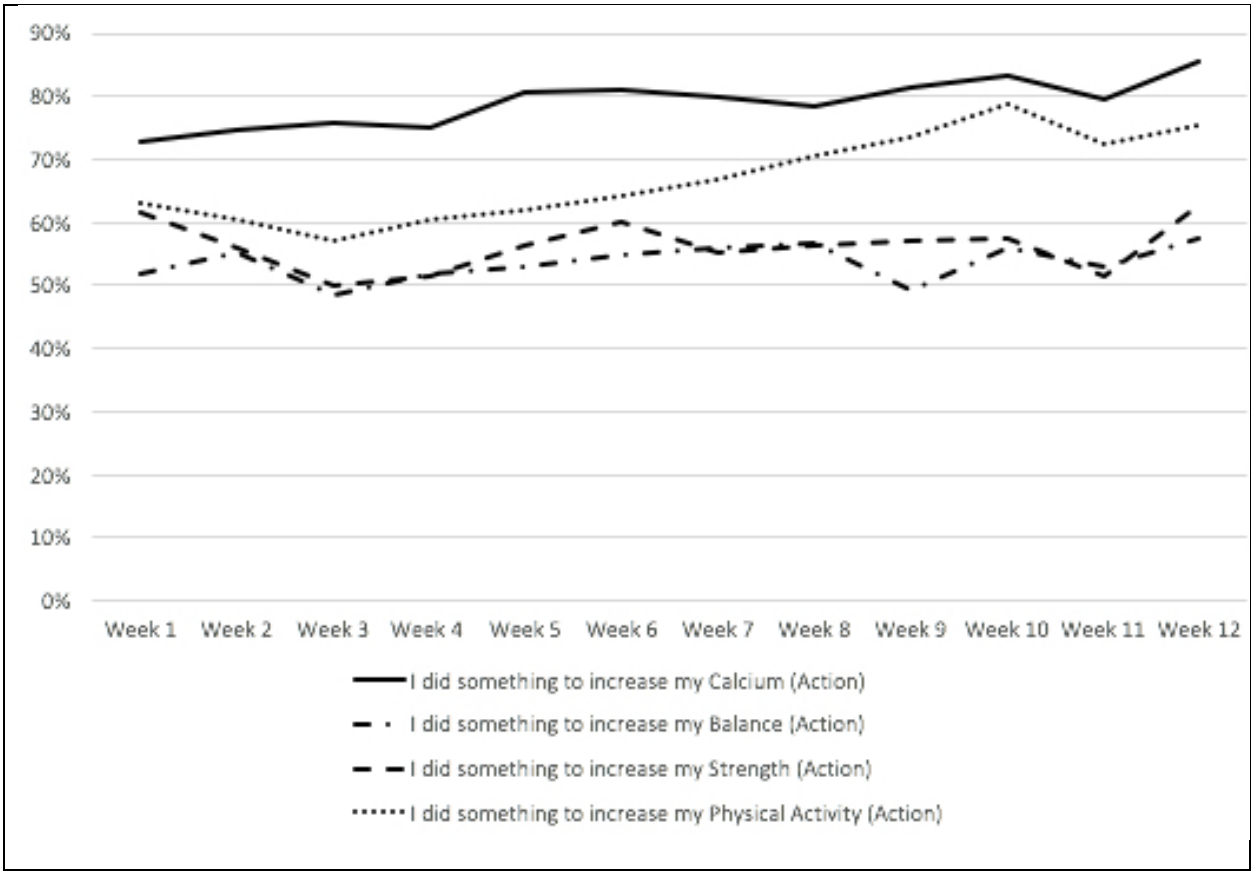

Figure 2. Percentages of EMAs affirming self-management behavior for calcium, physical activity, strength, and balance according to week in study

Discussion

This study's examination of women's engagement in the self-regulation process across four osteoporosis prevention areas revealed that women consistently reported having specific goals and plans for calcium intake, balance, strength, and physical activity throughout the first 12 weeks of study. After having specific goals and plans, self-monitoring was the next most frequently reported self-regulation activity for calcium and physical activity but not for balance and strength. For the latter two osteoporosis prevention areas, women reported more frequently engaging in self-evaluation than self-monitoring. Regardless of the osteoporosis prevention area considered, certain self-regulation activities described in theories and the literature, were not reported by this group of women – namely, emotional control, reflection, decision-making. The present study did not have access to an objective measure of health behavior change outcomes; therefore, to evaluate a self-reported behavioral outcome, this researcher examined participant responses to the EMA item: "I did something to increase my…" Though it is not discernible exactly what action the participant took, responding in the affirmative demonstrated that an action was taken. Participants most frequently reported "doing something" to change health behaviors related to calcium, followed by physical activity.

These findings reflect the importance of having specific goals, having specific plans, self-monitoring, and self-evaluating for the participants in the present study, with some variation according to the prevention area for the latter two self-regulation activities (i.e., self-monitoring was more frequently reported for calcium and physical activity than self-evaluation and the opposite is true for balance and strength). These findings regarding the preeminence of these four self-regulation activities is consistent with other health behavior change studies. Having specific goals has been identified in the literature as a consistent finding among individuals

engaged in health behavior change. A study by Middelkamp, van Rooijen, Wolfhagen, and Steenbergen (2016) testing two self-regulation interventions intended to promote group exercise behaviors found that selecting "self-set goals" assisted individuals in carrying out health behavior change. A number of randomized control trials have identified the role of the self-regulation activity of planning in mediating health behavior change, for example Lange et al. (2013) and Stadler, Oettingen, and Gollwitzer (2010). in Germany, Kellar and Abraham (2005) in England, Guillaumie, Godin, Manderscheid, Spitz, and Muller (2012) in Canada, and Kreausukon, Gellert, and Lippke (2012) in Thailand. In a study by Nurmi et al. (2016) investigating the relationship between motivation and physical activity, researchers found that this relationship was partially mediated by self-monitoring or tracking. Self-monitoring has been effective for diet and physical activity behavior change, especially when combined with other self-regulation activities (Michie, Abraham, Whittington, McAteer, & Gupta, 2009).

The variation in use of self-monitoring and self-evaluation could be explained by how easy or difficult it is to self-monitor or self-evaluate a particular behavior or whether participants considered it necessary to continue self-monitoring or self-evaluating a behavior change they believe they had mastered. Regarding balance and strength, both of these areas had lower percentages, when compared to calcium and physical activity, for the self-regulation activity of self-monitoring. There are a number of possible explanations for the lack of self-monitoring: the intervention did not adequately prepare participants to self-monitor these areas, participants did not feel confident in their abilities to self-monitor (self-efficacy), or participants may not have seen the value in self-monitoring these areas.

The fact that participants in the present study did not utilize the entire breadth of theoretically-derived self-regulation activities suggests that how self-regulation and health

behavior change theories depict the self-regulation process is not necessarily how participants actually engage in the process. This study's results suggest that individuals more commonly rely on a select few self-regulation activities, with some variation according to the specific behavior being targeted. This study's findings run contrary to many characterizations of the health behavior change process that set forth an iterative process whereby people analyze and evaluate actions in comparison to individualized standards, resulting in eventual correction of actions that are not consistent with these personal standards (Kanfer & Gaelick, 1975). Participant responses showed limited engagement is these analytical and self-evaluative components of the health behavior change process (e.g., decision-making, self-evaluation, reflection). If these self-regulation activities were utilized by participants, they did not identify their experiences as being commensurate with the EMA response options available.

Outcome: Participant Reported Self-Management Behaviors

The second EMA item queried participants on the self-regulation activities they used and whether or not they achieved any self-management behavior (outcome) during the first 12 weeks in the study. The EMA response "I did something to increase my…" was used to evaluate if a self-management behavior had been performed. Though it is not discernible exactly what action the participant took regarding any particular osteoporosis prevention area, responding in the affirmative demonstrates that an action was taken. Calcium, followed by physical activity, were the most frequently reported areas that participants "did something" to change health behaviors.

Examining EMA responses on a weekly basis, Calcium showed a slight gradual increase over the course of the 12 weeks (Calcium was the most frequently reported area for the SR Activity of 'action' for the entire 12 weeks). Physical activity, the second most frequently reported area, declined over the course of the first 3 weeks and then began a gradual upward

trend from Weeks 3 though 10. Strength and Balance had overlapping trajectories, with fluctuating increases and decreases in reported action over the course of 12 weeks, but the overall trend lines remained relatively flat compared to calcium and physical activity. Though the literature has a paucity of studies that investigate Calcium intake as a health behavior change, a study by Koetaka, Ohno, and Morimoto (2013) examined change patterns in self-reported health behaviors that included a similar dietary recommendation (i.e., eating breakfast). Koetaka et al. (2013) examined seven health behavior trends among 7,080 Japanese males over 9 years. Of the seven health behaviors examined, eating breakfast was the behavior adhered to by the highest proportion of participants. According to Koetaka et al. (2013), this behavior had a high keep rate, meaning change in the behavior did not occur easily and the behavior was consistent over time. Physical activity had the lowest keep rate meaning that changes occurred easily and the characteristic of the health practice obtained at one point in time was difficult to maintain. Consistent with the current study's findings, Koetaka et al.'s (2013) results suggest that health behaviors are not all equal in terms of how easily they are achieved and how consistently they are maintained over time.

Doing something to increase physical activity was the second most frequently reported action (after Calcium intake) according to EMA responses, but the pattern of engagement in this action over 12 weeks was characterized by greater variability than calcium intake. These findings are similar to recent literature that examines physical activity and the concept of fluctuation. Fluctuation was first described in relation to physical activity by Berlin Exercise Stage Model (BSM) as a stage when intermittent physical activity occurs (Fuchs, 1999). Fluctuation has also been characterized as a temporary cessation or fall from a higher to a lower stage of physical behavior (Stetson et al., 2005). Shang, Duan, Huang, and Brehm's (2018)

conducted a systematic review of fluctuation in the physical activity behavior literature that included 15 studies. Results of reviewing these studies revealed that 15-30% of adults are "fluctuators" who occasionally meet physical activity recommendations but experience frequent lapses (Shang et al., 2018). Examining the week-by-week trend line of EMA responses to the 'action' SR Activity for Physical Activity (Figure 2), the results are consistent with the concept of fluctuation.

Doing something related to strength and balance were the two areas with the lowest percentage of EMA responses. As was observed with physical activity, the pattern of EMA responses for strength and balance may be explained, in part, by fluctuation. The instability of balance and strength responses may be due to other factors. Shang et al.'s (2018) review identified limited volition, self-control, and unfavorable circumstances as potential factors for explaining fluctuations in behavior change. Another explanation could simply be that participants did not consider strength and balance to be problem areas for them, though research investigating these areas as contributing to disability among women suggests that balance and strength are generally poorer in women in this age range than for age-matched men (Kuh, Bassey, Butterworth, Hardy, & Wadsworth, 2005).

Strengths and Limitations

One of the major limitations of this secondary analysis study was restricted data access. Only being able to use a relatively small sample of individuals from the intervention arm of the parent study limited this researcher's ability to conduct comparative analyses of the EMA data. Descriptive studies such as this one, that lack a comparison group, prevent researchers from making inferences about causal association, another limitation of the present study. This sample was also relatively homogenous in terms of age, ethnicity, and race – only 2% of participants

were Hispanic, compared to the 15% Hispanic population in the county were most participants lived, and 77% of participants held undergraduate and graduate degrees, compared to 30% of county residents holding an undergraduate degree or higher (U.S. Census Bureau, 2017). Future investigations of the health behavior change process would include a more diverse sample with regards to these characteristics.

Future research should assess the validity of measuring self-regulation by EMA via text messaging by correlating these responses to other measures such as pedometer readings (an objective measure of tracking) or laboratory values (for measuring vitamin D and calcium levels). Another concern with the use of text messaging is that this EMA delivery method unintentionally became a reminder to participants to engage in health behavior change related to one or more of the osteoporosis prevention areas, instead of simply measuring their focus areas and SR Activity engagement.

Thought the researcher of the present study had no control over the sampling schedule, the variation in the quantity of EMAs delivered to participants was problematic for analysis since participants did not receive a consistent number of EMA throughout the course of the study. Given the high response rate to EMAs for the present and other studies using this measurement strategy, it is reasonable to conclude that participants would have responded to EMAs sent four times per day throughout the 12 weeks. Using a variable EMA sampling schedule that waned as the study progressed is problematic when trying to measure an unfolding process – surveying a participant only once a day may not be sufficient querying to capture a concept such as self-regulation.

A final concern is the operationalization of the self-regulation concept. The potential responses that participants could select to measure SR activity engagement and self-management

behaviors were not part of a psychometrically tested measure. Therefore, it is contestable how well the responses clearly represent the SR activities and self-management behaviors. For example, the response that corresponds to goal-setting was "I had a specific goal." However, this response is ambiguous in terms of whether or not this goal was a new goal set since the previous EMA or whether or not it was the same goal that the participant was simply reporting that she maintained. The response corresponding to self-evaluation was "I wanted to meet my goal but took care of other things instead." This phrase was used to operationalize self-evaluation by the primary investigator of the intervention study. In a study by Schüz, Wurm, Warner, Wolff, and Schwarzer (2014) assessing health motives of older adults, researchers defined the concept of health motives as "the importance of health relative to other life domains" (p. 496). In light of Schüz et al.'s (2014) definition of health motives, the phrase used to operationalize self-evaluation might actually be measuring health motives. These are two examples of how the response items for the EMAs may not have captured the self-regulation concept accurately. The accuracy and clarity of these EMA items could be improved by conducting item testing and a more thorough literature reviews of operationalization of the self-regulation concept.

Conclusion

Though health behavior change literature provides evidence that individuals initiate change (Haberman et al., 2017), to date researchers and clinicians lack a clear understanding of how individuals engage in the process of pursuing health goals. Rather, the focus of many health behavior change studies was on intervention design and testing. This study demonstrated an initial effort to analyze EMAs completed during the first 12 weeks of an intervention study to

gain insight into how individuals who are actively pursuing health behavior change engage in the theoretically-constructed process of self-regulation.

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CHAPTER 5

Discussion

Main Findings

The aim of the present study was to use valid, real-time EMA measurements to provide a rich description of self-regulation and the osteoporosis prevention areas that participants reported engaging in during their initiation of health behavior change. This chapter will discuss, organized by Research Question, the findings from the current study and their relation to health behavior change literature. Implications for future research, practice, and policy will also be explored. The major findings from the current study were:

- Research Question 1:
  - Finding 1: **Participants reported engaging predominantly in the osteoporosis prevention areas of Calcium intake (most prevalent), followed by Physical Activity for Weeks 1 through 12**. Balance and Strength had similarly low levels of engagement reported for Weeks 1 through 12.
- Research Question 2:
  - Finding 1: **SR Activities reported most frequently, across all 12 weeks, were having a specific goal and planning**. **This held true for all four osteoporosis prevention areas.** However, beyond these two self-regulation activities, there was divergence among the four osteoporosis prevention areas. For Calcium intake and Physical Activity, self-monitoring was the next most commonly reported SR activity. For Balance and Strength, the next most commonly reported SR activity was self-evaluation, not self-monitoring.
  - Finding 2: **Across all four osteoporosis prevention areas, SR Activities that had consistently low percentages were decision-making** (making a decision to modify or change a goal), **emotional control** (feelings affecting abilities), and **reflection** (thinking about reasons why plans worked or did not work).
- Research Question 3:
  - Finding 1: **Participants reported doing something (i.e., engaging in self-management behaviors) to increase their Calcium intake more frequently than any other activity for the entire 12-week time period.** Self-management behaviors related to Physical Activity was the next most frequently reported activity.

The purpose of the current study was to describe osteoporosis prevention areas focused on and SR activities utilized by participants actively initiating heath behavior change as part of

an intervention study to promote osteoporosis prevention through a theoretically-driven smartphone app. The study provided this description by analyzing participant reporting on osteoporosis prevention areas and SR activities using EMAs. The vast majority of studies that employ EMAs as a measurement technique do so to measure discrete events such as participants' medication adherence (Montes, Medina, Gomez-Beneyto, & Maurino, 2012), experience of symptoms from chronic conditions (Smyth, Wonderlich, & Crosby, 2002), and engagement in unhealthy behaviors such as smoking (Gwaltney, Shiffman, Balabanis, & Paty, 2005). The results of this study are unique in that they focus on individuals self-reported, real-time engagement in disease *prevention* and measures engagement in a theoretically-described *process* of health behavior change, self-regulation.

Research Question 1: Osteoporosis Prevention Areas of Focus

Research Question 1 was intended to determine if, during the initiation of health behavior change, there were differences in participants reported engagement in the four potential osteoporosis prevention areas emphasized by the primary study's intervention. The current study used responses to the EMAs to determine that Calcium, followed by Physical Activity, were the osteoporosis prevention areas that participants focused most on improving during the first 12 weeks of the study. This finding is an addition to the literature that has not specifically examined differential engagement in a variety of osteoporosis health behaviors related to disease prevention, including strength and balance training, despite the fact that the National Osteoporosis Foundation and clinician guidelines recommend these activities (Cosman et al., 2014). Studies that include health behavior change interventions related to osteoporosis prevention, consistently focus on calcium intake and physical activity as the health outcomes of importance, without incorporating balance and strength (Geum Oh et al., 2014).

In trying to understand why women in the present study reported focusing on calcium and physical activity more so than balance and strength, mediators of health behavior change were considered. Schwarzer (2008) examined seven studies that considered the role of different mediators on initiation and adherence to health behaviors such as physical activity and dietary behaviors. These seven studies revealed that significance of motivational processes (that result in an intention to change, such as self-efficacy) and volitional processes (that result in successful performance of change, such as strategic planning) when it came to initiating and maintaining change. Therefore, the lack of reported engagement in balance and strength in the current study may be attributable to gaps in either or both of these two processes. For example, the current study's participants may have been motivated to improve balance and/or strength but lacked adequate volitional training from the primary study's intervention (e.g., training in self-monitoring, planning, self-evaluation), or the volitional elements may have been in place, but self-efficacy, a motivational process, was not adequate enough to prompt participants' to maintain focus on the strength and balance osteoporosis prevention areas advocated by the primary study's intervention.

Another possible explanation for calcium and physical activity being more prevalently reported than balance and strength is that the intervention itself did not effectively guide women as to how to change balance and strength. These two focus areas have in common the fact that the intervention app provided participants with pre-recorded videos demonstrating how to perform a variety of strength and balance exercises that were recommended. Participants could review the videos multiple times, and they included written and audio-narrated directions on how to perform individual exercises. Both the physical activity and calcium components of the intervention did not follow this structure, but rather provided written suggestions for physical

activities and a searchable listing of calcium-rich foods. Participants may have found the video format unappealing for learning balance and strength exercises, and this delivery method might have required consistent reviewing of content until exercises were committed to memory, a possible barrier to change.

Participants' focus on physical activity and calcium could also be explained by the fact that, in the United States, a considerable emphasis is placed on physical activity and diet modification by healthcare providers, media, and advertisers. Whether or not people actually follow recommendations, diet and exercise modification are consistently being advocated, and a variety of prevalent chronic illnesses and potential acute health events are linked to poor diet and physical inactivity (e.g., hyperlipidemia, coronary artery disease, stroke). Hence, diet modification and physical activity are more familiar to the public as sources of health behavior change advocacy and therefore they more likely to elicit engagement, if only in the short-term, from participants.

Research Question 2: Engagement in Self-Regulation Activities

Research Question 2 was intended to describe actual use of SR activities during the initiation of health behavior change. EMA results corresponding to the second EMA question asked participants to report, in real time, on their use of SR Activities related to each of the four osteoporosis prevention areas. All four osteoporosis prevention areas demonstrated a pattern of consistently high percentages for having a specific goal and having specific plans throughout Weeks 1 through 12. However, each osteoporosis prevention area reveals a slightly different pattern of SR Activity reporting over the 12 weeks, demonstrating the uniqueness of the behavior change process for each area.

For Calcium, having a specific goal, having specific plans, and tracking are consistently

high, but tracking responses dwindled as weeks progressed, showing intermittent decreases and increases over time, but still reported more frequently than the other four self-regulation activities (e.g., emotional control, self-evaluation, decision-making, reflection). The pattern for physical activity is similar in that specific goals, specific plans, and tracking are the uppermost trend lines; however, tracking overlaps with "I really wanted to meet my goal but took care of other things instead" (this response corresponds to SR Activity of self-evaluation). And for both Balance and Strength, having a specific goal and having specific plans are the most frequently reported SR Activities across the 12 weeks; however, "I really wanted to meet my goal but took care of other things instead" consistently surpasses tracking.

These findings reflect the importance of having specific goals and having specific plans for the participants in the current study, with tracking being more prevalent for Calcium and Physical Activity than for Balance and Strength. These findings regarding the preeminence of goal-setting and planning SR Activities is consistent with other health behavior change studies. Having specific goals has been identified in the literature as a consistent finding among individuals engaged in health behavior change. A study by Middelkamp, van Rooijen, Wolfhagen, and Steenbergen (2016) testing two self-regulation interventions intended to promote group exercise behaviors found that selecting "self-set goals" assisted individuals in carrying out health behavior change. A number of randomized control trials have identified the role of the self-regulation activity of planning in mediating health behavior change, for example Lange et al. (2013) and Stadler, Oettingen, & Gollwitzer (2010) in Germany, Kellar and Abraham (2005) in England, Guillaumie, Godin, Manderscheid, Spitz, and Muller (2012) in Canada, and Kreausukon, Gellert, & Lippke (2012) in Thailand. In a study by Nurmi et al. (2016) investigating the relationship between motivation and physical activity, researchers found

that this relationship was partially mediated by self-monitoring or tracking. Self-monitoring has been effective for diet and physical activity behavior change, especially when combined with other self-regulation activities (Michie, Abraham, Whittington, McAteer, & Gupta, 2009).

While having specific goals and plans appear to be at the forefront of participants self-reported SR Activities, tracking appears to be differentially engaged in, depending on the osteoporosis prevention area under consideration. This could be explained by how easy or difficult it is to track a particular behavior or whether or not participants consider it necessary to continue tracking a behavior change they believe they mastered. Regarding balance and strength, both of these areas had lower percentages of reported engagement, when compared to calcium and physical activity, for the SR activity of tracking. There are a number of possible explanations for the lack of tracking: the intervention did not adequately prepare participants to self-monitor these areas, participants did not feel confident in their abilities to track (self-efficacy), or participants may not have seen the value in tracking these areas.

While the literature supports the current study's finding regarding the prevalence of having specific goals, having plans, and tracking, few studies to date have asked participants to report on their engagement in all three of these self-regulation activities nor have these studies asked participants to report their use of other aspects of self-regulation such as emotional control, self-evaluation, decision-making, and reflection. Studies including the concept of self-regulation tend to incorporate self-regulation as a component of an intervention rather than assessing people's actual use of the process.

Examining EMA data across four distinct disease prevention areas has revealed that all individuals do not apply SR Activities to target behaviors in an entirely standardized manner – while goal-setting and planning are prevalent across all four areas, self-reported engagement in

tracking varied by prevention areas as did whether or not an individual reported practicing self-evaluation The fact that participants in the current study did not equally employ the entire breath of theoretically-derived SR Activities could suggest that what SR and HBC theories associate with the process of changing health behaviors is not how participants actually engage in the process. The current study's results suggest that individuals more commonly rely on a select few SR Activities, but that there is some variation according to the specific behavior being targeted. Reported use of SR Activities also varies over time, as was the case with Calcium intake, were tracking was reported as a high percentage of SR Activities at the beginning of the 12 weeks, but gradually declined as the study progressed.

The current study's findings run contrary to many characterizations of the health behavior change process that set forth an iterative process whereby people analyze and evaluate behaviors in comparison to individualized standards, resulting in eventual correction of actions that are not consistent with these personal standards (Kanfer & Gaelick, 1975). Participant responses showed minimal engagement is these analytical and self-evaluative components of the health behavior change process (e.g., decision-making, self-evaluation, reflection). If these SR Activities were utilized by participants, they did not identify their experiences as being commensurate with the EMA response options available.

Research Question 3: Self-Management Behaviors

The second EMA question queried participants on the self-regulation activities they were engaged in during the first 12 weeks in the study. The response "I did something to increase my…" was the used by the researcher to evaluate a self-management behavior outcome. Though it is not discernible exactly what behavior the participant performed regarding any particular osteoporosis prevention area, responding in the affirmative demonstrates that a behavior was

undertaken. Calcium, followed by physical activity, were the most frequently reported areas that participants "did something" to change health behaviors.

Examining EMA responses on a weekly basis, calcium showed a gradual and slight increase over the course of the 12 weeks. Physical activity, the second most frequently reported area, declined over the course of the first 3 weeks and then began a gradual upward trend from Weeks 3 though 10. Strength and Balance had overlapping trajectories, with fluctuating increases and decreases in reported self-management behaviors over the course of 12 weeks, but the overall trend lines remained relatively flat compared to calcium and physical activity. Though the literature has a paucity of studies that investigate calcium intake as a health behavior change, a study by Koetaka, Ohno, and Morimoto (2013) examined change patterns in self-reported health behaviors that included a similar dietary recommendation (i.e., eating breakfast). Koetaka et al. (2013) examined seven health behavior trends among 7,080 Japanese males over 9 years. Of the seven health behavior examined, eating breakfast was the behavior adhered to by the highest proportion of participants. According to Koetaka et al. (2013), this behavior had a high keep rate, meaning change in the behavior did not occur easily and the behavior was consistent over time. Physical activity had the lowest keep rate meaning that changes occurred easily and the characteristic of the health practice obtained at one point in time was difficult to maintain. Koetaka et al.'s (2013) findings suggest that health behaviors are not all equal in terms of how easily they are achieved and how consistently they are maintained over time.

Doing something to increase physical activity was the second most frequently reported self-management behavior according to EMA responses, but the pattern of engagement in this outcome over 12 weeks is characterized by greater variability than calcium intake. These findings are similar to recent literature that examines physical activity and the concept of

fluctuation. Fluctuation was first described in relation to physical activity by Berlin Exercise Stage Model (BSM) as a stage when intermittent physical activity occurs (Fuchs, 1999). Fluctuation has also been characterized as a temporary cessation or fall from a higher to a lower stage of physical behavior (Stetson et al., 2005). Shang, Duan, Huang, Brehm's (2018) conducted a systematic review of fluctuation in the physical activity behavior literature that included 15 studies. Results of reviewing these studies revealed that 15-30% of adults are "fluctuators" who occasionally meet physical activity recommendations but experience frequent lapses (Shang et al., 2018). Examining the week-by-week trend line of EMA responses for Physical Activity (Manuscript 3 Figure 1), the results are consistent with the concept of fluctuation.

Doing something related to strength and balance were the two areas with the lowest percentage of EMA responses. As was observed with physical activity, the pattern of EMA responses for strength and balance may be explained, in part, by fluctuation. The instability of balance and strength responses may be due to other factors. Shang et al.'s (2018) review identified limited volition, self-control, and unfavorable circumstances as potential factors for explaining fluctuations in behavior change.

Implications for Future Research

As previously discussed, Calcium and Physical Activity were the most prevalent osteoporosis prevention areas women reported focusing on while participating in an intervention study that included four rather disparate target areas for change (calcium intake, physical activity, balance, and strength). One of the implications for future research is considering the efficacy of multiple health behavior change (MHBC) interventions, not only for osteoporosis, but other aspects of health as well including health promotion (physical activity, diet), disease

prevention (health screenings), addictive behaviors (smoking), and disease-related behaviors (cardiovascular disease). Researchers such as Unger (1996) have observed that some focus areas for health behavior change serve as a catalyst to expanding the scope of change to other areas. For example, adults working on quitting smoking had more healthful levels of alcohol use and exercised more than those not intending to quit smoking. Similarly, a 7-year prospective observational study of 750 Japanese men found that increased habitual exercise was associated with quitting smoking, conversely, smoking relapse was associated with decreased habitual exercise (Nagaya, Yoshida, Takahashi, & Kawai, 2007).

In the current study, Calcium intake a Physical Activity were reported at similarly higher frequencies than the other two osteoporosis prevention areas. However, depending on the health areas of focus there could be underlying common factors across multiple target areas, or one behavior could serve as the impetus or a coping strategy for another. Calcium-rich foods, such as dairy, have traditionally been associated with high-calorie diets. Though there are dairy-alternatives to increasing calcium intake, the majority of the U.S. population still associate increasing calcium intake with increasing dairy intake (IOM, 2010). Though participants in the current study were not asked to report on this concern, weight management increasingly becomes an issue for both men and women during middle age, which encompasses current study participants (Newton, Russell, & McAdams, 2017). Hence, during a time of life involving increased susceptibility to weight gain, this study asked participants to focus on increasing calcium intake from diet, which is often associated with increasing calories consumed. There is a reasonable synergistic relationship, therefore, between calcium intake being a particular area of focus along with physical activity, given that physical activity may have been the area participants also engaged in as a way of off-setting increased calories from calcium intake. This

is just one plausible explanation for a possible relationship between two of the prevention areas that had similarly high responses frequencies. Future research on health behaviors outside of osteoporosis prevention would seek to intervene on common factors that link different target areas, remove common stimuli for unhealthy behaviors that co-occur (e.g., tobacco and illicit drugs use), and teach effective coping and general principles of health behavior change, which lead to widespread changes across multiple target areas.

With regards to the last point above, teaching general principles of health behavior change, the findings of Research Question 2 suggest that people are using fewer of the SR activities than many health behavior change theorists and interventionists postulate. If health behavior change literature presupposes that the behavior change process for different target areas is similar, the current study, though descriptive, suggests that participants do report using some of the same process-related activities across different target areas (e.g., goal-setting, planning). The larger revelation garnered from the current study is that the SR activities that participants do report using most frequently during behavior initiation are much more limited in scope than proposed by health behavior change theories and interventions. The results of the current study regarding SR activities could be a function of the fact that the current study only examined the first 12 weeks of data, and perhaps participants did start incorporating more emotional control, reflection, and decision-making as time in study progressed. Regardless, results of the current study suggest that is worth examining actual use of SR activities across a variety of health and lifestyle situations (e.g., chronic disease management, addiction, health promotion) to determine if the pattern of high reported use of goal-setting, planning, and self-management behaviors are consistently reported in different domains. Conversely, it is also critical, for both theory and intervention development, to assess, with different health conditions and populations, whether or

not the lesser reported SR activities from the current study are persistently unused by people enacting health behavior change.

In addition to investigating potential mechanisms of engagement in different behavior clusters (e.g., calcium intake and physical activity both being reported at higher frequencies that strength and balance), a better understanding of why strength and balance were less frequently reported prevention areas of focus could help inform future interventions designed with these areas in mind. Such knowledge could be gained from a secondary qualitative study of the primary study in which researchers interviewed participants and questioned them on factors influencing their decisions to focus on one area over another. Similarly, qualitative study could be used to ask participants of the current study narrative their perceived process of health behavior change. These narratives could serve as a gateway to hypothesizing potential relationships between different target areas.

Although EMAs were an ideal approach for describing a health behavior change process as it was unfolding, some aspects of EMA use were problematic. One of the flaws was part of the EMA language itself. The EMA asked participants to consider: "Since the last time I answered one of these questions, I have done something related to one or more of the following activities." This phrasing of the EMA questions was somewhat contrary to the essence of the EMA measurement strategy intention. EMAs are idea for describing thoughts, feelings, experiencing *in the moment* when the survey is delivered. As the EMA questions read, the participant was being asked to recall engagement in activities over a variable span of time that depended on when they last answered an EMA. That time span could have been 1 hour between EMAs or closer to 2 days for some participants, because of the changing EMA schedule as the primary study progressed and the fact that the primary study used rolling enrollment, so not all

participants started the study at the same time. The advantage that EMAs had to offer over traditional measurements is that they capture behavior and experiences as they were happening. Asking participants to recall information "since the last time…" they received an EMA caused the EMA data to be fraught with the same types of recall difficulties as other conventional survey techniques.

Another opportunity to improve the EMAs in future research is also in the vein of improved precision – specifically, providing participants with an opportunity to accurately report on their SR activities. For example, the outcome measured by the EMAs asked participants to respond yes or no as to whether or not they "did something" to increase their Calcium intake, Balance, Strength, or Physical Activity. Given the format of the EMAs, researchers never had the opportunity to collect information on precisely what they participants were doing or whether or not they were doing anything different from one EMA to the next (e.g., is the participant consistently drinking milk each time she reported, via EMA, "doing something" to increase calcium, or was consuming other foods?). The format of the EMAs made the details of SR activities impossible to determine since there was no opportunity for short-answer responses. Future research would consider revising EMAs to incorporate chances for participants to provide more detailed information regarding activities, behaviors, thoughts, attitudes, etc. Making minor modifications to the EMA format to allow for short answer, in justifiable circumstances, could improve understanding of the phenomenon under study while retaining the attractive attributes of EMAs (e.g., ecologically valid, brief, low participant burden, easy to complete).

There are arguable advantages to utilizing a real-time measurement strategy to assess the self-regulation process, which occurs through numerous moment-to-moment decisions that happen through a given day. However, future research using EMAs should seek to correct

ambiguities regarding the time period being measured by using precise language that is not left to individual interpretation. In the primary study, revising EMA questions to reflect participant activities in the moment could have been easily accomplished by phrasing the question: "At this moment, are you doing anything related to one or more of these four areas?" Another concern regarding EMAs in the current study was the wide variability in the number of EMAs completed per participant (minimum EMAs completed by one participant was 21; maximum completed was 377). This circumstance was facilitated by the fact the EMAs were not required by the primary study (i.e., participants were not at risk of being removed from the study for not completing the EMAs). Studies employing EMAs could achieve more consistent response frequencies from participants if EMA completion was requirement to be considered an active study participant.

A final consideration for future research is in regards to potential reactivity when using EMAs as a measurement strategy. Minimal research into the reactivity of EMAs has been conducted to date yet the influence of EMAs, independent of any other study aspects, on participant thoughts, behaviors, and attitudes is a threat to both internal and external validity (Magnan, Köblitz, McCaul, & Dillard, 2013). According to Hufford and Shiffman (2003), reactivity refers to "the degree to which the intensity, frequency, and/or quality of a dependent variable changes as a function of the assessment itself" (p. 79). For the limited study of reactivity and EMAs, most of this research has come from the field of addiction and has revealed inconsistent findings. For example, Shiffman et al. (2002) indicated that EMAs themselves might reduce smoking behavior, independent of any smoking cessation intervention, while Rowan et al. (2007) suggested that there were no significant changes in smoking behavior compared to a non-EMA receiving control group. EMAs may also effect the concomitants of

health behaviors (e.g. thoughts, attitudes, impulses), although examination of these constructs related to reactivity is also limited.

Although EMAs have not been applied to measuring a health behavior change process such as self-regulation prior to this study, future research employing EMAs as a measurement strategy should at minimum consider the potential for reactivity and develop design strategies for how to address this potential threat to study validity. Future research should include a non-EMA control group to which outcomes could be compared. Without a control group, it is difficult to determine if the change in behavior is due to the EMA procedures or some other aspect of the study. In the case of the primary study, the question could be raised, was the intervention influencing participants process of health behavior change or was it the EMAs continually asking participants if they had engage in any self-regulation activities? Participants also received the exact same EMAs, which could have resulted in habituation to the questions and responses.

To summarize the recommendations for future research in the field of health behavior change include: 1) improvement in the precision of the language of EMAs, including operationalization of the construct under measurement and clearer definition of time frames being assessed, 2) promotion of consistent EMA responses by making completion of EMAs a contingency for continued participation in a study, 3) design of studies to include non-EMA control groups to allow evaluation of whether or not change in participants' behaviors, thoughts, attitudes, etc. is due to the EMAs themselves or some other study factor (e.g., intervention), 4) repeated measures using EMAs should employ a variety of question formats to assess the same constructs – repeated exposure to the same questions places the participants and study at risk for decreased responsiveness to the EMAs through habituation.

Implications for Practice

The current study's results demonstrate that participants differentially prioritized Physical Activity and Calcium intake over strength and balance. Though women participating had no prior diagnosis of osteoporosis, participants did carry risk factors (e.g., advancing age, cigarette smoking, alcohol consumption, post-menopausal status). Participants' willingness, or reluctance, to enact health behavior change in the four recommended prevention areas could be influenced by their illness representations (emotional and cognitive processing of health threats), including their perceptions of the efficacy of different prevention areas. Leventhal's common-sense model (CSM) of illness representations delineates how people respond to health threats by developing both cognitive and emotional responses. Cognitive illness representations include cause, timeline, consequences, perceptions about identity (labels and/or symptoms associated with the illness), and control of the illness. Emotional illness representations are feelings such as sadness, anxiety, or anger linked to the illness (Leventhal, Meyer, & Nerenz, 1980). Healthcare practitioners measuring illness representation at time of initial patient assessment or admission could help address patients' perceived risk factors and attitudes towards prevention areas, which could aid in tailoring clinician recommendations and disease-prevention strategies.

In the context of this study, knowing that participants focused less of Balance and Strength despite the importance of engaging in all four osteoporosis prevention areas is a forewarning to practitioners that these areas may require further intervention, patient teaching, and exploration of perceived barriers and patient health beliefs/values (e.g., does the patient see achieving self-management outcomes [symptom control, pharmacotherapy] as a priority). Development and utilization of disease-specific risk assessment tools could provide a realistic

picture of an individual's absolute and relative risks and increase personal risk awareness (Bussoletti, 2003). Participants in this study, who received an intervention that emphasized engaging in all four prevention areas, focused more so on Physical Activity and Calcium intake – understanding participant rationales for this differential focus could influence clinical practice as well as intervention design.

Study results have the potential to inform clinical practice because they revealed the SR activities that participants reported engaging in most frequently. Clinicians can capitalize on this new knowledge by incorporating the three common SR activities into their patient interactions (teaching these SR activities, modeling them, providing patients opportunities to practice and demonstrate their mastery of SR activities). To help individuals develop and practice self-regulation activities, it may be beneficial to hold nurse-led group sessions organized around particular health conditions to ensure that participants were pursuing similar self-management behaviors (e.g., individuals with chronic asthma seeking to improve forced expiratory volume [FEV1] as a means of reducing disease-related symptoms and prevent exacerbations). The group sessions could include social cognitive strategies focused on learning and practicing self-regulation activities (e.g., successful participants role-modeling their use of self-regulation activities to facilitate observational learning).

In terms of the less frequently reported SR activities (e.g., decision-making, reflection, self-evaluation, emotional control), additional efforts may need to be made on the part of clinicians to teach and assess these SR activities, and even then, SR activities may not be uniformly applied by individuals across health behaviors. For a patient with a history of cancer, conducting self-exams may more prominently involve emotional control than an individual with no previous diagnosis.

Implications for Policy

Public awareness of osteoporosis pathology, risk factors, and prevention is suboptimal according to a number of studies. A large survey conducted by Rizzoli et al. (2010) found that one third of postmenopausal women could not identify any risk factors for osteoporosis. Evidence exists that even for individuals with high awareness of their osteoporotic risk (high awareness seen in women diagnosed with osteoporosis [Ní Chróinín, Glavin, & Power, 2013]), this awareness does not necessarily translate into longer-term behavioral change (Blalock, 2005). Osteoporosis is not alone – numerous health risks and diseases (e.g., cancer, cardiovascular disease, diabetes) have recommended health modifications that people avoid despite awareness of the potential consequences. One of the purposes of the current study was to describe what activities people actively pursuing change actually engage in as they began the behavior change process. In measuring participants' reported use of theory-driven, SR activities, the findings of this study indicate that a limited number of SR activities were relied on when initiating health behavior change across all four osteoporosis prevention areas. Namely, goal-setting, planning, and self-management behaviors were the most prevalent SR activities reported. Given that this is a single descriptive study, researchers cannot advocate ignoring decades of theory development and intervention testing that incorporates a wider array of SR activities such as emotional control, reflection, decision-making, and self-evaluation. However, it is relevant to theory, intervention, and public program development that individuals actively engaged in behavior change limited their use of self-regulation to three or four SR activities. At the very least, this finding suggestion a starting point for health behavior change policies that may consider beginning with this smaller number of SR activities and identify what impact that

limited scope of emphasis has on behavioral outcomes (e.g., can individuals initiate and maintain health behavior change with three or four vs seven or eight SR activities?)

While health education is necessary for health behavior change, it is not sufficient without the behavior change skill set necessary to engage in the process of change. Therefore, public health policy to bolster health education alone in schools, worksites, and communities are insufficient. The results of this study require experimental testing across multiple target areas using different behavior change frameworks. However, the current study's finding suggest that the SR activities are being utilized by people pursuing health behavior change. Therefore, health promotion and disease prevention policies could be bolstered by supporting public health initiatives to empower to engage in SR activities as they pursue behavior change – fostering these SR activities would allow people to actively pursue the health behavior change process in any setting and facilitate control over their own behaviors in circumstances where people often feel as if they have not control (e.g., acute illness, chronic illness, addiction).

Conclusion

The results of this study are unique in that they focus on individuals' self-reported, real-time engagement in disease *prevention* and measure engagement in a theoretically-described *process* of health behavior change, self-regulation. Results reveal that participants report focusing mostly on Calcium intake and Physical Activity, and they rely on the SR activities of goal-setting and planning, and perform self-management behaviors across all four osteoporosis prevention areas, with some osteoporosis prevention area-specific variation. The current study adds to the current health behavior change literature by identifying the osteoporosis prevention areas of focus for participants pursuing health behavior change in this prevention area when given multiple health behaviors to change (Calcium intake, Physical Activity, Balance, and

Strength). Opportunities still remain to understand the rationale as to why participants differentially focused on Calcium intake and Physical Activity, but there are a number of possible explanations (e.g., exposure to these areas in the media, lack of efficacy or perceived skills in each area, ineffectiveness of the intervention to draw participant focus). Goal-setting and planning, both self-regulation activities, and self-management behaviors are frequently reported in health behavior change literature; therefore, the current' study's findings were consistent with existing literature in this regard. However, health behavior change theories and interventions consistently include additional SR activities that participant in the current study reported lesser use of (e.g., reflection, emotional control, decision-making, self-evaluation). Future research would ideally investigate whether or not the limited scope of SR activities used remains consistent among different populations with different health threats or conditions. These investigations could include qualitative research involving semi-structured interviews asking participants to narrate their process for changing behaviors. Policy and practice would not only incorporate instruction in these specific SR activities, but also assessment of individual illness representations and perceived disease risk-assessments that capture people's rationales for focusing on or turning away from different SR activities and target areas for behavior change.

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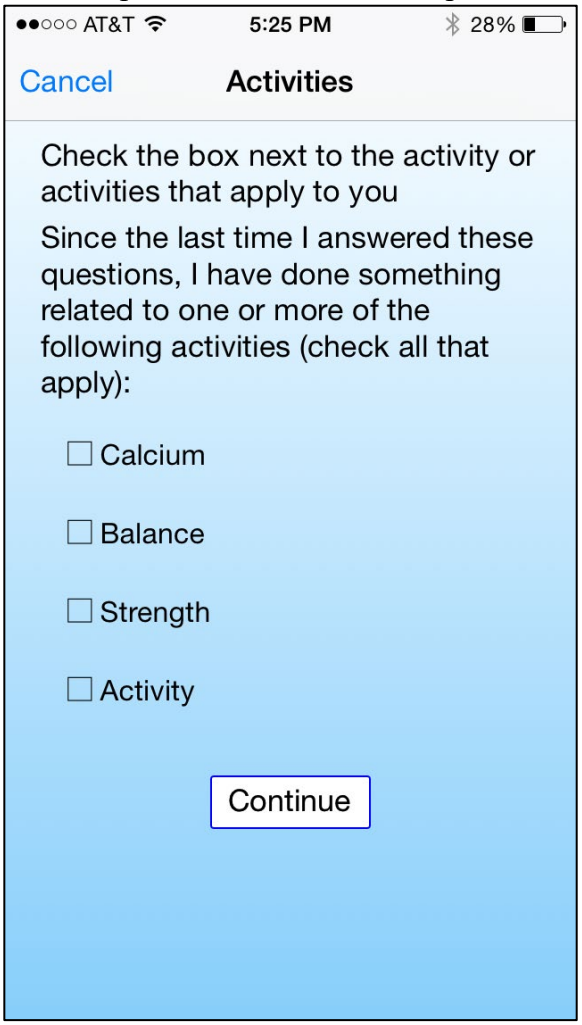
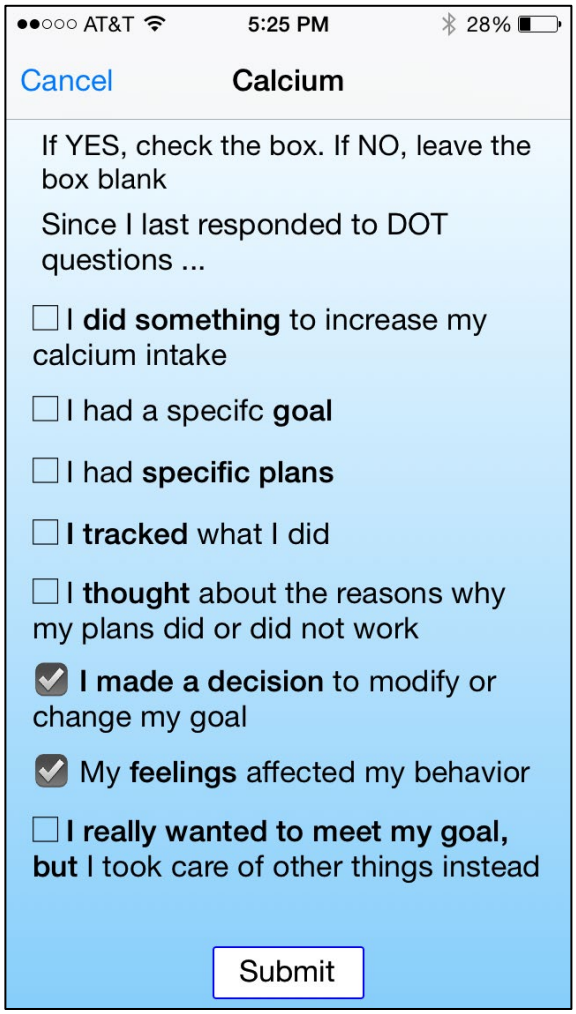
APPENDIX A:

Sample EMA with directions provided to participants and sample screenshots of EMAs



Instructions participant receives at baseline data collection session:

- ALL DOT Questions throughout the 12-month study are the same and follow the same format: First, Select the Activity or Activities – these activities are the 4 areas of Osteoporosis Prevention. **Select all that apply to you**. Take a minute to read the screen to the left. You will see this screen numerous times throughout the 12 month study
  REMEMBER, this question is asking you to remember what you did SINCE YOU LAST ANSWERED a DOT Question**.**



- For each Activity you checked in Part 1 of the DOT, you will see the screen shown to the right in Part 2 of the DOT.
- On this screen, you check the boxes (by tapping on them) that reflect your behaviors related to the Activity you checked in Part 1.
- **Take a minute or two to examine the list of behaviors now**. You will be answering this question multiple times during the 12-month study so you will become familiar with the behaviors listed in the DOT.
- **KEEP IN MIND…**if for Part 1 of the DOT, you selected Calcium AND Balance, you will see 2 of the screens shown to the right, one asking about Calcium and the next screen asking about Balance. You will know which screen corresponds to which Osteoporosis Prevention Activity because the Activity is listed at the top of the screen.

APPENDIX B:

IRB approval for current study

UNIVERSITY of WISCONSIN
UWMILWAUKEE

Department of University Safety & Assurances

Melissa Spadanuda
IRB Manager
Institutional Review Board
Engelmann 270
P. O. Box 413
Milwaukee, WI 53201-0413
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New Study - Notice of IRB Expedited Approval

Date: March 6, 2018

To: Rachel Schiffman, PhD
Dept: College of Nursing

Cc: Melissa Brown

IRB#: 18.201
Title: DESCRIPTION OF SELF-REGULATION ACTIVITIES OF OSTEOPOROSIS PREVENTION USING ECOLOGICALMOMENTARY ASSESSMENTS

After review of your research protocol by the University of Wisconsin – Milwaukee Institutional Review Board, your protocol has been approved as minimal risk Expedited under Category 5 as governed by 45 CFR 46.110. Your protocol has also been granted approval to waive informed consent as governed by 45 CFR 46.116 (d).

This protocol has been approved on March 6, 2018 for one year. IRB approval will expire on March 5, 2019. If you plan to continue any research related activities (e.g., enrollment of subjects, study interventions, data analysis, etc.) past the date of IRB expiration, a continuation for IRB approval must be filed by the submission deadline. If the study is closed or completed before the IRB expiration date, please notify the IRB by completing and submitting the Continuing Review form found in IRBManager.

Any proposed changes to the protocol must be reviewed by the IRB before implementation, unless the change is specifically necessary to eliminate apparent immediate hazards to the subjects. It is the principal investigator's responsibility to adhere to the policies and guidelines set forth by the UWM IRB, maintain proper documentation of study records and promptly report to the IRB any adverse events which require reporting. The principal investigator is also responsible for ensuring that all study staff receive appropriate training in the ethical guidelines of conducting human subjects research.

As Principal Investigator, it is your responsibility to adhere to UWM and UW System Policies, and any applicable state and federal laws governing activities which are independent of IRB review/approval (e.g., FERPA, Radiation Safety, UWM Data Security, UW System policy on Prizes, Awards and Gifts, state gambling laws, etc.). When conducting research at institutions outside of UWM, be sure to obtain permission and/or approval as required by their policies.

Contact the IRB office if you have any further questions. Thank you for your cooperation and best wishes for a successful project.

Respectfully,

Melissa C. Spadanuda
IRB Manager

Melissa A. Brown, MS, RN (License # 176922-30)

Education

University of Wisconsin, Milwaukee, WI
PhD in Nursing (defended/graduated December 2018)
Focus: Self-Management, Ecological Momentary Assessments
Dissertation: Description of Self-Regulation in Health Behavior Change Using Ecological Momentary Assessments

University of Wisconsin, Milwaukee, WI
Direct Entry Master's Program, College of Nursing
Master's in Nursing, Adult Clinical Nursing Specialist
Applied Gerontology Certificate
Fall 2009 – Spring 2012 (GPA 3.97)
Received RN License (State of WI): March 2011

University of Wisconsin, Madison, WI
Graduated in August of 2006 "with Distinction"
B.A. in Political Science, Spanish, and Psychology (GPA 3.96)

Work Experience

University of Wisconsin - Milwaukee, WI
Lead Instructor (N399 & N400: Combined Pathophysiology and Pharmacology) (Sept. 2016 – present)
• Providing didactic and interactive education to adult students admitted to the Nursing program
• Developing and grading exams, in-class activities, and assignments related to core concepts and systems for course topics
• Collaborating with co-instructors and coordinating with other courses across the curriculum to ensure that concepts are presented consistently across courses and that the timing of their presentation is thoughtfully considered
• Providing office hours and review sessions to meet with students who have additional questions or are seeking further understanding of a topic presented in the course
• Responding to student communications, requests, and feedback in a timely and efficient manner

Striving to be Strong **Research Assistant** - Milwaukee, WI
Research Assistant (May 2012 - present)
• Research assistant for NINR/NIH-funded osteoporosis prevention self-management study (Ryan, 1R01NR013913-01)
• Developing and revising study interventions, study protocols, and procedures in collaboration with research team consisting of nurses, physical therapists, physicians, and IT professionals (e.g., writing content for and testing functionality of patient-centered, individually-tailored self-management smartphone app, authoring self-regulation survey administered to participants)
• Conduct baseline and end of study data collection with study participants (responsibilities include administering physical measures, collecting blood samples for vitamin D testing, installing intervention [smartphone self-management app], providing participant education on intervention use, and conducting 1:1 study exit interviews)
• Collect and analyze data in collaboration with study PI and study biostatisticians
• Prepare reports and study materials for submission to NIH (e.g., preliminary data analysis report of specific physical function measures taken at baseline data collection)
• Maintain accurate records and data management systems, safeguarding participant confidentiality

• Request and acquire supplies and materials necessary for the study
• Attend multiple weekly meetings consisting of various team members and aimed at developing, maintaining, improving a variety of aspects of the study (e.g., recruitment and retention plans, study website, study protocols and procedures, data management, participant contacts)

Wheaton Franciscan Healthcare, St. Joseph's Hospital - Milwaukee, WI
Intensive Care Unit RN, Preceptor, & Charge Nurse (May 2012 - present) – **Clinical Nurse III**
• Providing comprehensive critical care for patients with a variety of diagnoses including both medical and surgical patients (e.g., stroke, encephalopathy, renal disease, liver failure, congestive heart failure, myocardial infarction, diabetic ketoacidosis, sepsis/septic shock, pneumonia, influenza, pneumothorax).
• Assuming leadership roles on the unit included advance training in continuous renal replacement therapy and intra-aortic balloon pump; precepting graduate nurses, nurse interns, and new nurse hires; serving as charge nurse for the unit, which entails managing staff and unit workflow
• Emergently treating patients undergoing life-threatening medical events using BLS and ACLS training.
• Monitoring patient for changes in condition and executing appropriate nursing interventions in collaboration with medical staff and other healthcare professionals (e.g., respiratory therapy, occupation therapy, physical therapy, dietician, speech therapy).
• Providing patient and family education and instruction regarding treatment plans, procedures, medications, lifestyle modifications, etc.
• Collaborating with attending physicians, intensivists, hospitalists, consulted physicians and nurse practitioners to develop a plan of care individualized to each patient.

University of Wisconsin - Milwaukee, WI
Nursing Teaching Assistant (Pathophysiology and Pharmacology courses) (Sept. 2010 – May 2014)
• Providing student education services and 1:1 tutoring for nursing students in Pathophysiology I and II, as well as Pharmacology courses required for all nursing majors.
• Leading scheduled study sessions for each course twice per week during the academic year.
• Providing support services for the Pathophysiology and Pharmacology professors as needed.
• Leading exam review sessions for students prior to each exam and creating learning materials and designing activities to help them better understand/retain core pathophysiology and pharmacology concepts.

Significant Professional Activities/Memberships

- Wisconsin Nurses Association – Member since June 2012
- American Association of Critical Care Nurses – Member since October 2012
- Quality Committee – Intensive Care Unit (Co-Chair) (Wheaton Franciscan - St. Joseph's Hospital)
- Practice/Development Committee – Intensive Care Unit (Member) (Wheaton Franciscan - St. Joseph's Hospital)
- Operations Committee – Intensive Care Unit (Member) (Wheaton Franciscan - St. Joseph's Hospital)
- Palliative Care Team – Intensive Care Unit (Member) (Wheaton Franciscan - St. Joseph's Hospital)
- Fall/Restraint Committee – Intensive Care Unit Chair (Wheaton Franciscan - St. Joseph's Hospital)
- American Heart Association – Advance Cardiovascular Life Support Certification (since September 2012)

Nursing Scholarships/Honors

- Phi Beta Kappa Member (induction May 2006)
- Sigma Theta Tau Nursing Honor Society (induction September 2010)
- Helen C. Bader Graduate Scholarship (received scholarship in May 2010 and again in May 2011)
- Chancellor's Award Scholarship (received May 2012 to fund three years of PhD education)
- Nominated for DAISY Award as nursing instructor at UWM (2017)
- DAISY Award winner for teaching (spring 2018)

Publications

Ryan, P., Papanek, P., Csuka, M., Brown, M., Hopkins, S., Lynch, S.,…Hoffman, R. (2018). Background and method of the Striving to be Strong study a RCT testing the efficacy of a m-health self-management intervention. *Contemporary Clinical Trials*, *71*, 80-87. doi: 10.1016/j.cct.2018.06.006