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Review

Sedentary Behavior Reduction: A Stepwise Approach to Increasing Physical Activity and Reducing Cardiovascular Disease Risk in Endometrial Cancer Survivors

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Abstract

Endometrial cancer survivors experience high rates of cardiovascular disease (*e.g., heart disease, obesity, diabetes*). The heightened cardiovascular disease risk may be attributed to cancer treatment coupled with sub-optimal lifestyle behaviors following treatment, including high amounts of sedentary behavior (SB). Public health agencies have graded the association of evidence between SB and cardiovascular disease as strong. However, while clinicians may wish to prescribe SB substitution strategies to reduce SB, guidelines do not currently exist. An additional challenge to behavior change pertains to the unique barriers that endometrial cancer survivors face, including treatment-associated fatigue and limited self-efficacy. Engaging in healthy movement behaviors, including minimizing SB and achieving recommended amounts of physical activity, are critical for health and well-being as well as cardiometabolic disease prevention. The purpose of this perspective paper is to propose an informed approach to physical activity promotion aimed to initiate movement and promote long-term behavior change by starting with an emphasis on reducing SB in endometrial cancer survivors. First, we address why endometrial cancer survivors should be targeted with SB reduction. Then, we suggest a stepwise approach to increasing physical activity by starting with SB reduction, including consideration to behavioral theories. Finally, we provide suggestions for future directions.

Keywords: sedentary behavior; endometrial cancer; lifestyle behavior; cardiovascular disease; behavior change

1. Introduction

Endometrial cancer has one of the highest survival rates with 96% living at least 5 years post-diagnosis [1]. However, compared to the general population, endometrial cancer survivors experience a 3 to 6 fold greater risk of cardiovascular disease (CVD) compared to women without cancer [2,3]. Moreover, CVD is the leading cause of death among early stage endometrial cancer survivors [4]. The heightened CVD risk can be attributed to obesity, metabolic syndrome [5], and sub-optimal lifestyle behaviors [3] such as high amounts of sedentary behavior (SB, defined as low-intensity activity in a seated/reclined posture with energy expenditure at or below 1.5 metabolic equivalents [6], Table 1, Ref. [6–15]) and physical inactivity (defined as insufficient amounts of physical activity that is not meeting guidelines [16], Table 1). Compared to several other types of cancer survivors (breast, prostate, colorectal, and ovarian), prevalence of obesity and physical inactivity among endometrial cancer was the highest [17]. Engagement in healthy movement behaviors [7], including meeting recommended guidelines for physical activity [18] and minimizing sedentary behavior [19] are critical for health and well-being and the prevention of secondary disease [20,21]. Physical inactivity and SB have been used interchangeably, however the two movement behaviors are distinct CVD risk factors [22–25]. Interrupting SB with light physical activity has health benefits independent from moderate-to-vigorous physical activity [26,27]. Yet, despite endometrial survivors spending the majority of their day in SB [28], survivorship programs have primarily focused on other modifiable health behaviors such as diet or physical activity [29–32], and much less is known regarding the optimal prescription of SB [33].

A working hypothesis is that SB contributes to CVD risk via repeated exposure to acute sitting-induced increases in arterial stiffness likely driven by hemodynamic changes with metabolic, autonomic, and hormonal factors [25]. During acute prolonged sitting, a lack of muscle pump ac-

Table 1. Key terminology including definitions of endometrial cancer and cardiometabolic disease as well as movement behaviors and health behavior strategies.

Key term	Definition	Reference
Endometrial cancer (EC)	Cancer of the endometrium (lining of the uterus). Cases are most commonly reported in women over 55 years of age. Symptoms such as abnormal vaginal bleeding often lead to early detection. If detected in early stages EC is highly treatable via surgery, chemotherapy, and/or radiation treatment.	[8]
Cardiometabolic disease (CMD)	Cardiometabolic diseases include cardiovascular disease, diabetes mellitus, and chronic renal failure. The cardiometabolic diseases represent a cluster of interrelated risk factors including hypertension, elevated fasting blood sugar, and abdominal obesity. Lifestyle risk factors also play a role in increasing CMD risk and include physical inactivity, smoking, and diet.	[9]
Lifestyle behaviors	Daily activities that are the result of an individual's values, knowledge, and norms shaped by broad cultural and socioeconomic environment. Engagement in physical activity and sedentary behavior as well as nutritional behaviors (i.e., vegetable consumption) are examples of lifestyle behaviors. Healthy lifestyle behaviors decrease an individual's risk for many chronic conditions including cardiovascular disease.	[10]
Movement behavior	Includes all physical activity, sedentary behavior, and sleep that occurs in a 24-hour cycle. Interaction between the three components of movement behavior patterns are associated with overall health and risk of chronic diseases such as cardiovascular disease.	[7]
Sedentary behavior (SB)	Any waking behavior characterized by an energy expenditure $\leq$1.5 metabolic equivalents (METs) while sitting, lying, or reclining. Examples of sedentary behavior: working at a desk, driving, watching TV, etc.	[6]
Physical activity (PA)	Any bodily movement produced by the contraction of skeletal muscle that increases energy expenditure above the resting metabolic rate (basal level). Types of physical activity include: exercise, occupational, conditioning, housework, etc. Physical activity is characterized by the **f**requency, **i**ntensity, **t**ime/duration, and **t**ype/modality. The characterization of PA is also known as the FITT principle.	[11]
Light-intensity physical activity	Any non-sedentary waking behavior that requires less than 3 METs. Examples: walking at a leisurely pace, light housework, and cooking.	[11]
Moderate-intensity physical activity	Activity that requires 3.0–5.9 METs. Examples: raking leaves and taking a brisk walk.	[11]
Vigorous-intensity physical activity	Activity that requires more than 6.0 METs. Examples: running, carrying heavy groceries upstairs, and strenuous fitness classes.	[11]
Physical inactivity	The term used to describe people who do not meet the recommended level of regular physical activity. Adults are considered physically inactive if they do not acquire at least 150 minutes of moderate-to-vigorous physical activity (MVPA) per week.	[11]
Theory of planned behavior	The theory of planned behavior suggests that an individual's intentions to perform a certain behavior can be predicted and influenced by three main factors: (1) attitude toward the behavior, (2) subjective norms, and (3) perceived behavioral control.	[12]
Implementation intentions	Synonymous with "if-then" planning, implementation intentions help bridge the gap between behavioral intention and actualization. Formulation of implementation intentions involves planning out when, where, and how goal-directed behaviors will be enacted to help individuals avoid self-regulatory pitfalls on the path toward goal realization. Setting implementation intentions promotes initiation and continuation of goal-directed behaviors even when faced with unwanted influences. An example of setting implementation intentions, "When my phone beeps three times, I will stand up for 30 seconds."	[13]
Mental Contrasting	A self-regulatory strategy that helps build strong goal commitment via increasing perceived self-efficacy. Mental contrasting involves comparatively visualizing a desired outcome followed by the realistic obstacles.	[14]
Intention-Behavior Gap	The failure to translate a goal intention into an actualized behavior.	[15]

tivity leads to lower extremity venous blood pooling and reduced blood transit time in venous circulation, which subsequently decreases venous return inversely with stroke volume [25,34]. Reduced stroke volume decreases shear stress which promotes oxidative stress, endothelial dysfunction, and acutely increases arterial stiffness [35–39]. Overtime with repeated exposure this may result in structural remodeling of vessel walls [25,40] potentially explaining the positive association between chronic SB and arterial stiffness [41] and between SB and CVD [42,43]. The purpose of this paper is to propose an informed approach to physical activity promotion aimed to initiate movement and sustain long-term behavior change by starting with an emphasis on reducing SB in endometrial cancer survivors. Specifically, we will (i) present key terminology (Table 1) and discuss existing literature examining SB in endometrial cancer survivors, (ii) present a stepwise approach to reducing SB, (iii) propose considerations for research on the stepwise approach, and (iv) conclude with practical implications.

2. Risk for CVD and Potential Role of Activity Behaviors

2.1 Endometrial Cancer Survivors are at High Risk for CVD

Endometrial cancer is the 4th most commonly diagnosed cancer in women [44], and with 5-year survival exceeding 90% [1] there is a large population of survivors. However, endometrial cancer survivors are more likely to die from CVD then their cancer [4]. Furthermore, unlike many other cancers, endometrial cancer incidence is growing with more cases being diagnosed every year likely due to the increasing obesity epidemic, with many shared risk factors between endometrial cancer and obesity [45,46]. Factors that contribute to obesity risk (*i.e., insulin resistance*) are also associate with endometrial cancer risk [47]. However, risk of death from CVD is greater than risk of death from endometrial cancer five years after diagnosis with an age-adjusted standardized mortality ratio of 8.8 (95% confidence interval 8.7–9.0) [3,48]. In a Surveillance, Epidemiology, and End Result (SEER) study, Ward *et al.* [3], report that over time the probability of CVD increases in endometrial cancer survivors and calls for investigation into potential survivorship interventions aimed at targeting CVD risk reduction.

2.2 Endometrial Cancer Survivors and Poor Activity Behaviors

An estimated 80% of survivors of endometrial cancer are overweight/obese and spend a large amount (>8 hours per day) of time sedentary [28,49], posing a significant threat to their well-being and health-related quality of life [50]. However, existing literature investigating SB in endometrial cancer survivors is currently limiting by data only including questionnaire (not objective accelerometry data) [51]. The majority of survivors exhibit the motivation to change these patterns of behavior in wake of their cancer diagnosis [50] but only about half of cancer survivors in general receive consultation on improving activity behaviors [52]. Furthermore, it is not clear why endometrial cancer survivors are sedentary. There is a moderate level of evidence linking sitting time and endometrial cancer [53], but significantly less evidence pertaining to why endometrial cancer survivors are sedentary and the behavioral determinants influencing activity behaviors. Information regarding SB in endometrial cancer survivors is currently limited by the majority of the evidence being cross-sectional survey data. More research is needed to better understand this multidimensional behavior in endometrial cancer survivors as each cancer survivorship group has unique needs depending on the biology of the disease, patient characteristics, and effects of treatment [54]. For example, early-stage endometrial cancer is curative with surgery yet patients (who are likely obese and have multiple comorbidities) [54] need survivorship interventions improve lifestyle behaviors to improve cardiometabolic disease burden.

Despite substantial evidence of the benefits of physical activity such as CVD risk reduction and disease prevention [55], participation is extremely low. An estimated 80% of US adults do not meet recommended physical activity levels (≥150 mins of moderate-to-vigorous intensity physical activity per week) [56] likely due to barriers such as lack of time, access, or knowledge [57,58]. One study of N = 120 early-stage endometrial cancer survivors found that 88.3% were physically inactive [54] despite physical activity being correlated with quality of life in endometrial cancer survivors [59]. We hypothesize that the existing physical activity interventions do not account for the specific challenges that survivors face such as low physical function, obesity, fatigue, and neuropathy (Table 2) [60–64]. Participation in physical activity is even lower in clinical populations such as those with endometrial cancer who are burdened with barriers and challenges from cancer treatment such as low physical function, pain, obesity, neuropathy, and fatigue [60–64]. As physical inactivity and SB are distinct risk factors [65], individuals meeting recommended guidelines for physical activity engagement (150 min/week) are not fully protected from the detrimental cardiovascular effects associated with SB.

There is a growing presence of both movement behaviors (physical activity and SB) in public health guidelines [66]. However, the recommendations for reducing SB are far less specific vaguely stating “sit less and move more” [66]. There are critical gaps in SB interruption recommendations that need to be filled including frequency, intensity, time (duration), and type (modality such as standing or walking). Our best evidence for breaking up SB to reduce CVD risk includes interruptions every 20–30 minutes using a light intensity activity like walking for 2–5 minutes [67]. However, existing evidence does not account for special populations, like endometrial cancer survivors, who may

Table 2. Challenges endometrial cancer survivors face to healthy lifestyle engagement and how sedentary behavior interruption may address these concerns.

Barriers to physical activity engagement	Consequences of barriers for endometrial cancer survivor	How sedentary behavior interruption strategies address barriers
Obesity	Restricts movement, limits fitness, joint stress	Low skill, limited exertion, closed chain movements to limit joint strain and reduce risk of injury
Low physical fitness	Chronic disease risk, limited muscular strength and endurance, low cardiorespiratory fitness	Utilizes low MET activities of daily living—walking or standing—to avoid overexertion, incrementally increase fitness, and improve quality of life
Fatigue	Reports of being too tired to exercise, mental health impact (feeling discouraged), contributes to sedentary behavior	Requires less time than exercise, uses movements that are already needed in daily life, and limits exertion
Pain	Restricts movement, limits fitness, contributes to sedentary behavior	Utilizes low impact, modifiable movements to minimize stress on the body
Neuropathy	Restricts movement, contributes to balance challenges	Can be completed with physical support (i.e., walker or counter-top for balance), relieves pressure in the lower extremities. Can involve predominantly static activities (i.e., standing) = reduces the need for physical support in patients with neuropathy in their upper extremities
Low self-efficacy	Lack of motivation and lack of self-belief	Utilizes movements requiring a low skill level and minimal instruction which increases confidence in one's ability to complete task
Limited physical activity experience	Lifetime of physical inactivity, previous poor experience with physical activity, chronic poor lifestyle movement behaviors	Easier to start standing and/or walking than engaging in exercise, can be completed at home with little resources

need tailored recommendations and have greater risk for CVD [4]. For example, the ACSM physical activity guidelines provide specific recommendations for special populations like cancer survivors, who made need different SB interruption prescription (frequency, dose, type) but more SB research is needed before we have enough evidence to create such prescription. Furthermore, current guidelines do not provide recommendations addressing promotion from SB interruption to regular engagement in physical activity. The progression from reducing to SB to meeting physical activity guidelines is critical for individuals to reap the benefits of physical activity. However, current guidelines do not include progression strategies.

2.3 Activity Behavior Interventions in Endometrial Cancer Survivors Have Had Limited Success

Despite strong evidence of endometrial cancer survivors engaging in high amounts of SB [50], there is a clear lack of interventions targeting SB reduction. Additionally, there are limited physical activity interventions targeting endometrial cancer survivors. Existing literature reports improvement in quality of life following physical activity (*i.e., walking*) interventions [63,68–70], but concerningly there are frequent reports of adherence and compliance [68,70] issues even greater than the general population. Furthermore, a qualitative study conducted by Koutoukidis *et al*. [71] reported endometrial cancer survivors experience many challenges and barriers to physical activity engagement (i.e., time, financial, and geographical constraints; treatment effects; obesity-related stigma social; and a lack of information/instruction) and express a clear lack of knowledge on what activity they should be trying to complete (frequency, intensity, time, and type).

In terms of SB reduction interventions, findings in individuals with obesity can guide our understanding regarding some of the unique challenges endometrial cancer survivors face. For example, Judice *et al*. [72] conducted a pilot study to evaluate the short-term effectiveness and feasibility of prompting SB interruption in individuals with obesity throughout the workday and during home/leisure time activities. Results indicated the intervention strategy was successful in reducing SB and increasing the amount of time spent standing/walking per day. Upon review of participant feedback, it was clear that participants responded to the prompts by increasing the length of standing/light physical activity bouts and preferred this time adjustment to more frequent interruptions in SB [72]. The authors reported behavioral resistance to more frequent sit to stand transitions. It appears participants with obesity do not prefer more frequent SB interruptions (with a shorter duration), but instead would rather increase the duration of the interruption with walking or standing (decreasing frequency of interruption). In a population of older adults, Hartman and colleagues [73], conducted a long-term (16 weeks) SB intervention study during which, the intervention was adjusted based on participant feedback to intensify coaching

and support during the latter portion of the study. These adjustments ultimately led to a significant decrease in SB and increase in PA (light intensity) among individuals at high risk for CVD. A strong foundational understanding of the needs of the population is critical to support feasibility, since an intervention will only work if participants are willing to adhere to it. Design components aimed to promote long-term adherence to SB interventions in special populations (e.g., endometrial cancer survivors) are lacking and constitute a methodological pitfall common in SB intervention design and study approach. The results from Judice *et al*. [72] and Hartman *et al*. [73] emphasize that active inclusion of participant feedback is important for the development and modification of feasible interventions suited to the target population that will facilitate easy habituation and long-term adoption of the intervention [72].

2.4 Endometrial Cancer Survivors Face Unique Challenges to Activity Engagement

Endometrial cancer survivors face many challenges to engaging in healthy movement behaviors such as low physical function [63], cancer related fatigue [60,61], obesity [62], pain [63], and limited self-efficacy [64]. Compared to other types of cancer survivors, endometrial cancer survivors in particular engage in higher amounts of SB [53]. Endometrial cancer survivors are also highly inactive [74]. Evidence suggests that physical activity engagement provides clear benefits for CVD prevention and survivorship such as enhanced quality of life [68]. However, only an estimated 12–29% of endometrial cancer survivors meet physical activity guidelines [59,75]. Reducing SB may be a feasible strategy to reduce CVD burden in endometrial cancer survivors because interruptions strategies such as standing or walking may be more feasible for this population that is commonly both deconditioned and overweight/obese [76]. Additionally, SB reduction likely requires fewer resources (e.g., education, cost, time) than changing other CVD related lifestyle behaviors (e.g., physical activity, diet, sleep). When aiming to improve lifestyle behavior in endometrial cancer survivors, reducing SB may be a critical first step that may lead to subsequent physical activity engagement.

3. A Stepwise Approach to Increasing Physical Activity

3.1 A Proposed Stepwise Approach to Improving Activity Behaviors in Endometrial Cancer Survivors

As the prevalence of CVD in endometrial cancer survivors continues to increase, it is necessary to move beyond "sit less and move more" in an effort to prescribe specific guidance to reduce SB [56]. Recent research [66,77] into preventative measures has increasingly focused on the relationship between SB and chronic disease. This includes exploring the impact of SB reduction on disease risk independent of and in conjunction with physical activity interventions. Dogra *et al*. [78], suggests an approach to clinical physical activity counseling that starts with reducing SB. The proposed stepwise approach recommends clinicians begin with motivational interviewing designed to assess their patients' current SB and physical activity habits along with their motivation and ability to change said habits (Fig. 1). If clinician time constraints limit the feasibility of implementation, then perhaps they could provide a referral (i.e., to see a nutritionist and/or physical therapist) or handout such as Fig. 1 instead. However, provider recommendations regarding diet and exercise are associated with beneficial changes in cancer patients' lifestyle behaviors [79]. For patients who are sedentary and/or do not meet physical activity guidelines, the stepwise approach [78] suggests healthcare teams (*i.e., clinicians, researchers, nurses, physician assistants, physical therapists, psychologists, etc*.) begin with SB counseling. Since endometrial cancer survivors face additional challenges to healthy lifestyle engagement, and individuals with obesity display behavioral resistance to frequent SB interruptions [72], we suggest the stepwise approach to increase physical activity should begin by targeting SB once per hour.

The goal of stepwise SB counseling is to interrupt prolonged SB and increase the amount of sit to stand transitions (ideally, 2–5 per hour) [78]. Since changing lifestyle behaviors may be met with behavioral resistance, theoretically informed behavioral counseling approaches employing goal-setting [78] and mental contrasting [80] need to be prioritized. Increasing the duration of the interruption appears to be the first step then individuals should work to increase the frequency of the SB interruptions over time [72]. Once the individual has successfully adopted the goals of step one (increased sit to stand transitions) into their daily routine, the clinician/researcher/healthcare team member will help them move on to and through step two which involves participation in light intensity physical activity (*i.e., walking, household chores, gardening, playing with pets*). The third step involves a progression towards incorporating moderate physical activity (*i.e., resistance training, brisk walk, jog, biking*) and the fourth step involves vigorous physical activity (*i.e., running, jumping, swimming, heavier resistance training*). The final step includes reaching a level of cardiorespiratory and musculoskeletal fitness that is associated with positive overall health outcomes such as reduced CVD risk. In the final step, maintenance of recommended physical activity and SB reduction will be achieved. By beginning with reducing SB, the stepwise approach [78] addresses many of the most commonly cited barriers to physical activity among endometrial cancer survivors, including physical limitations to exercise, fatigue, time constraints (interrupting SB requires less time than traditional physical activity/exercise engagement), transportation (SB reduction can occur at home or at work) [56]. The stepwise approach [78] to SB reduction is also grounded in behavioral theory, potentially making it a feasible strategy to use in endometrial cancer survivors [80].

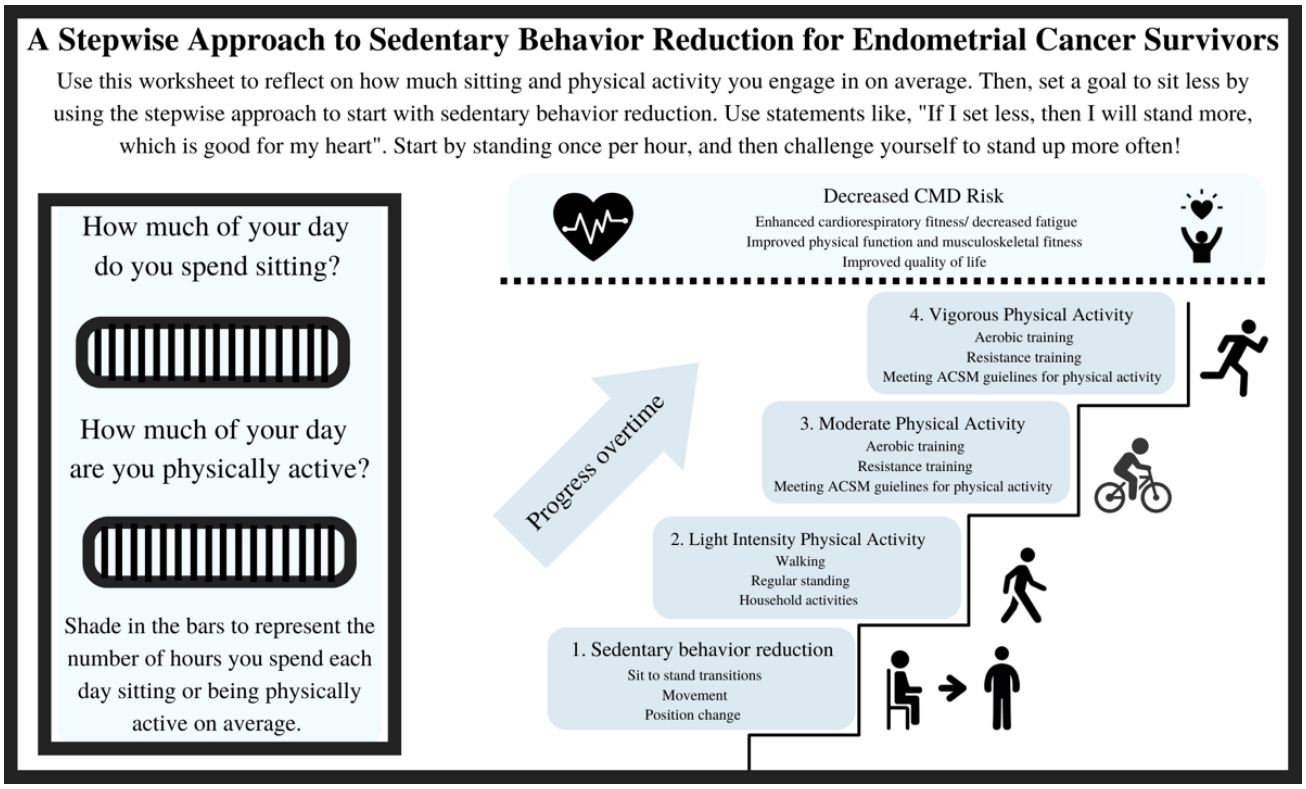

Fig. 1. Stepwise Approach to Sedentary Behavior Reduction for Endometrial Cancer Survivors. This figure represents a worksheet that could be distributed to endometrial cancer survivors when they are waiting for their appointment to start in clinical settings. The endometrial cancer survivor will self-reflect, and shade in the circles to represent how much time they spend sitting or being physically active per day. It also gives examples of goal setting, and provides easy to follow steps to increase physcial activity by starting with sedentary behavior reduction.

3.2 Considerations for Research on Stepwise Approach

The overarching goal of research should be to inform policy that provides clear guidelines to promote health and well-being. Current guidelines for SB reduction are lacking in specificity and fail to include special populations that are at higher risk for CVD such as endometrial cancer survivors. Endometrial cancer survivors are amenable to lifestyle changes during follow-up care [17,81]. However, these patients struggle to successfully implement lifestyle changes to improve their health-related quality of life and increase long-term survivorship. A recent study conducted by the American Society of Clinical Oncology (ASCO) found that only 56.87% of respondents reported discussion about exercise during visits to their oncologists, thus it is likely that many cancer patients are unaware of their inactivity and its impact [79]. Thus, in adapting SB and physical activity interventions for endometrial cancer survivors, it is crucial to eliminate as many of the population-specific challenges to facilitate long-term behavior change. For example, handouts and conversations with their oncologist about diet and exercise serve to educate cancer patients about PA and SB as well as direct them toward helpful resources. When researchers and clinicians design interventions utilizing the stepwise approach, behavioral theories to promote enhancing self-efficacy will likely make long-term maintenance of healthy lifestyle behaviors more feasible. A recent meta-analysis reports a significant relationship between an individual's confidence in their ability to reduce SB and lower levels of SB (combination of objective and self-reported SB measurement) [82] suggesting that self-efficacy may be a critical factor in reducing SB in endometrial cancer survivors. Increases in self-efficacy has resulted in initiating leisure-time walking within sedentary women after and implementation intentions intervention [83].

Implementation intentions aim to promote initiation of goal-oriented behaviors, encourage behavioral maintenance when presented with unwanted obstacles, and promote accessibility and automaticity of goal-directed responses [84]. Implementation intentions (or making "if-then" plans) should be used in conjunction with mental contrasting, a self-regulatory strategy, the intended goal with realistic obstacles [84]. "If-then" plans foster sustained behavioral change by creating goal-directed behaviors and attaching them to external cues which ultimately promotes initiation and automaticity of these behaviors (*i.e., "When my phone beeps three times I will stand up for 30 seconds."*). Mental contrasting is also important in creating effective implementation intentions [14] because it pre-

emptively creates an achievement-focused mental structure for approaching adversity and promotes a goal-oriented response to unwanted influences/obstacles. These behavioral techniques should be integrated into the first step of the stepwise approach (Fig. 1) and then maintained throughout to increase physical activity by starting with SB reduction.

The lack of success in translating SB interventions from non-clinical populations to endometrial cancer survivors can be described as a result of the intention-behavior gap [85]. The gap between goal intentions and goal achievement is common problem inhibiting behavior change in all of us to some extent. The intention-behavior gap is often a result of multiple interacting factors [85]. In the case of endometrial cancer survivors, the gap between strong goal intentions—to change physical activity and/or SB—and long-term lifestyle changes is due, in large part, to a disproportionate number of obstacles that are not accounted for in typical physical activity interventions. Endometrial cancer survivors need a behavioral approach to increase self-efficacy and increase their resilience against obstacles in order to implement lifestyle behavior change. Successful integration of behavioral techniques into—properly adapted—SB interventions for endometrial cancer survivors will promote initial behavior change and progress maintenance. Therefore, we suggest a stepwise approach [78] to reduce SB will successfully lead to increased physical activity long-term compared to traditionally implementing physical activity without consideration for behavior chance to maintenance.

4. Conclusions

Endometrial cancer survivors experience high risk of CVD due to cancer treatment and sub-optimal lifestyle behavior such as high amounts of SB and physical inactivity. Challenges to healthy lifestyle engagement such as fatigue, obesity, low physical function, pain, and low self-efficacy have led to limited success in interventions improving lifestyle activities. To successfully motivate lifestyle behavior, change and to enhance self-efficacy in endometrial cancer survivors, behavioral strategies should be integrated in the development of interventions. This paper presents a stepwise approach that could be implemented by providers to increase sustainable physical activity overtime. Although future research is needed to test the effectiveness of a stepwise approach to SB reduction in endometrial cancer survivors, we hypothesize that a stepwise approach starting with SB reduction supported by behavioral theories may be a feasible strategy to lead to long-term physical activity engagement for endometrial cancer survivors.

Author Contributions

LB, MD, EH, and LS designed the article. LB, MD, EH, JM, VBJ, MM, and LS wrote the manuscript. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

Ethics Approval and Consent to Participate

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Conflict of Interest

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References

[1] Surveillance, Epidemiology, and End Results (SEER) program (www.seer.cancer.gov) SEER*Stat Database: Survival Rates for Endometrial Cancer. Released April 2022. Available at: https://seer.cancer.gov/statfacts/html/corp.html (Accessed: 14 April 2022).

[2] Lees B, Hampton JM, Trentham-Dietz A, Newcomb P, Spencer R. A population-based study of causes of death after endometrial cancer according to major risk factors. Gynecologic Oncology. 2021; 160: 655–659.

[3] Ward KK, Shah NR, Saenz CC, McHale MT, Alvarez EA, Plaxe SC. Cardiovascular disease is the leading cause of death among endometrial cancer patients. Gynecologic Oncology. 2012; 126: 176–179.

[4] Soisson S, Ganz PA, Gaffney D, Rowe K, Snyder J, Wan Y, *et al*. Long-term Cardiovascular Outcomes Among Endometrial Cancer Survivors in a Large, Population-Based Cohort Study. Journal of the National Cancer Institute. 2018; 110: 1342–1351.

[5] Fader AN, Arriba LN, Frasure HE, von Gruenigen VE. Endometrial cancer and obesity: Epidemiology, biomarkers, prevention and survivorship. Gynecologic Oncology. 2009; 114: 121–127.

[6] Gibbs BB, Hergenroeder AL, Katzmarzyk PT, Lee I, Jakicic JM. Definition, Measurement, and Health Risks Associated with Sedentary Behavior. Medicine & Science in Sports & Exercise. 2015; 47: 1295–1300.

[7] Ross R, Chaput J, Giangregorio LM, Janssen I, Saunders TJ, Kho ME, *et al*. Canadian 24-Hour Movement Guidelines for Adults aged 18–64 years and Adults aged 65 years or older: an integration of physical activity, sedentary behaviour, and sleep. Applied Physiology, Nutrition, and Metabolism. 2020; 45: S57–S102.

[8] The American College of Obstetricians and Gynecologists. Endometrial Cancer. 2019. Available at: https://www.acog.org/womens-health/faqs/endometrial-cancer (Accessed: 15 April 2022).

[9] de Waard AM, Hollander M, Korevaar JC, Nielen MMJ, Carlsson AC, Lionis C, *et al*. Selective prevention of cardiometabolic diseases: activities and attitudes of general practitioners across Europe. European Journal of Public Health. 2019; 29: 88–93.

[10] Bailey RR, Phad A, McGrath R, Haire-Joshu D. Prevalence of five lifestyle risk factors among U.S. adults with and without stroke. Disability and Health Journal. 2019; 12: 323–327.

[11] U.S. Department of Health and Human Services. Physical Activity Guidelines for Americans. 2018.
[12] Ajzen I. The theory of planned behavior. Organizational Behavior and Human Decision Processes. 1991; 50: 179–211.
[13] Gollwitzer PM, Sheeran P. Implementation Intentions and Goal Achievement: a Meta-analysis of Effects and Processes. Advances in Experimental Social Psychology. 2006; 78: 69–119.
[14] Oettingen G, Gollwitzer P. Strategies of setting and implementing goals: Mental contrasting and implementation intentions. 2010.
[15] Sheeran P, Webb TL. The Intention-Behavior Gap. Social and Personality Psychology Compass. 2016; 10: 503–518.
[16] González K, Fuentes J, Márquez JL. Physical Inactivity, Sedentary Behavior and Chronic Diseases. Korean Journal of Family Medicine. 2017; 38: 111.
[17] Hardcastle SJ, Glassey R, Salfinger S, Tan J, Cohen P. Factors influencing participation in health behaviors in endometrial cancer survivors. Psycho-Oncology. 2017; 26: 1099–1104.
[18] Liguori G, Medicine AC of S. ACSM's guidelines for exercise testing and prescription. Lippincott Williams & Wilkins: USA. 2020.
[19] Tremblay MS, Aubert S, Barnes JD, Saunders TJ, Carson V, Latimer-Cheung AE, *et al*. Sedentary Behavior Research Network (SBRN) – Terminology Consensus Project process and outcome. International Journal of Behavioral Nutrition and Physical Activity. 2017; 14: 75.
[20] McGregor DE, Palarea-Albaladejo J, Dall PM, del Pozo Cruz B, Chastin SFM. Compositional analysis of the association between mortality and 24-hour movement behaviour from NHANES. European Journal of Preventive Cardiology. 2021; 28: 791–798.
[21] Chaput J-P, Carson V, Gray CE, Tremblay MS. Importance of All Movement Behaviors in a 24 Hour Period for Overall Health. International Journal of Environmental Research and Public Health. 2014; 11: 12575–12581.
[22] Matthews CE, George SM, Moore SC, Bowles HR, Blair A, Park Y, *et al*. Amount of time spent in sedentary behaviors and cause-specific mortality in us adults. The American Journal of Clinical Nutrition. 2012; 95: 437–445.
[23] Koster A, Caserotti P, Patel KV, Matthews CE, Berrigan D, Van Domelen DR, *et al*. Association of Sedentary Time with Mortality Independent of Moderate to Vigorous Physical Activity. PLoS ONE. 2012; 7: e37696.
[24] English C, Janssen H, Crowfoot G, Bourne J, Callister R, Dunn A, *et al*. Frequent, short bouts of light-intensity exercises while standing decreases systolic blood pressure: Breaking up Sitting Time after Stroke (BUST-Stroke) trial. International Journal of Stroke. 2018; 13: 932–940.
[25] Stoner L, Barone Gibbs B, Meyer ML, Fryer S, Credeur D, Paterson C, *et al*. A Primer on Repeated Sitting Exposure and the Cardiovascular System: Considerations for Study Design, Analysis, Interpretation, and Translation. Frontiers in Cardiovascular Medicine. 2021; 8: 716938
[26] Ekelund U, Steene-Johannessen J, Brown WJ, Fagerland MW, Owen N, Powell KE, *et al*. Does physical activity attenuate, or even eliminate, the detrimental association of sitting time with mortality? A harmonised meta-analysis of data from more than 1 million men and women. The Lancet. 2016; 388: 1302–1310.
[27] Young DR, Hivert M, Alhassan S, Camhi SM, Ferguson JF, Katzmarzyk PT, *et al*. Sedentary Behavior and Cardiovascular Morbidity and Mortality: a Science Advisory from the American Heart Association. Circulation. 2016; 134: e262–e279
[28] Bates LC, Zieff1 G, Stoner L, Hanson ED. Negative 24-hour movement behaviors in cancer populations: clustering of physical activity, sedentary behavior, and sleep. American College of Sports Medicine Annual Meeting. San Diego, CA. 2022. Medicine & Science in Sports & Exercise. 2022.
[29] McCarroll ML, Armbruster S, Frasure HE, Gothard MD, Gil KM, Kavanagh MB, *et al*. Self-efficacy, quality of life, and weight loss in overweight/obese endometrial cancer survivors (SUCCEED): a randomized controlled trial. Gynecologic Oncology. 2014; 132: 397–402.
[30] Smits A, Lopes A, Das N, Bekkers R, Massuger L, Galaal K. The effect of lifestyle interventions on the quality of life of gynaecological cancer survivors: A systematic review and meta-analysis. Gynecologic Oncology. 2015; 139: 546–552.
[31] Smits A, Lopes A, Das N, Bekkers R, Massuger L, Galaal K. Exercise Programme in Endometrial Cancer; Protocol of the Feasibility and Acceptability Survivorship Trial (EPEC-FAST). BMJ Open. 2015; 5: e009291.
[32] Koutoukidis DA, Beeken RJ, Manchanda R, Michalopoulou M, Burnell M, Knobf MT, *et al*. Recruitment, adherence, and retention of endometrial cancer survivors in a behavioural lifestyle programme: the Diet and Exercise in Uterine Cancer Survivors (DEUS) parallel randomised pilot trial. BMJ Open. 2017; 7: e018015.
[33] Katzmarzyk PT, Powell KE, Jakicic JM, Troiano RP, Piercy K, Tennant B. Sedentary Behavior and Health: Update from the 2018 Physical Activity Guidelines Advisory Committee. Medicine & Science in Sports & Exercise. 2019; 51: 1227–1241.
[34] Horiuchi M, Stoner L. Effects of compression stockings on lower-limb venous and arterial system responses to prolonged sitting: a randomized cross-over trial. Vascular Medicine. 2021; 26: 386–393.
[35] Kinlay S, Creager MA, Fukumoto M, Hikita H, Fang JC, Selwyn AP, *et al*. Endothelium-Derived Nitric Oxide Regulates Arterial Elasticity in Human Arteries in Vivo. Hypertension. 2001; 38: 1049–1053.
[36] Wilkinson IB, Qasem A, McEniery CM, Webb DJ, Avolio AP, Cockcroft JR. Nitric Oxide Regulates Local Arterial Distensibility in Vivo. Circulation. 2002; 105: 213–217.
[37] Stewart AD, Millasseau SC, Kearney MT, Ritter JM, Chowienczyk PJ. Effects of Inhibition of Basal Nitric Oxide Synthesis on Carotid-Femoral Pulse Wave Velocity and Augmentation Index in Humans. Hypertension. 2003; 42: 915–918.
[38] Stoner L, Stone K, Zieff G, Blackwell J, Diana J, Credeur DP, *et al*. Endothelium function dependence of acute changes in pulse wave velocity and flow-mediated slowing. Vascular Medicine. 2020; 25: 419–426.
[39] Thosar SS, Johnson BD, Johnston JD, Wallace JP. Sitting and endothelial dysfunction: the role of shear stress. Medical Science Monitor. 2012; 18: RA173–RA180.
[40] Kucharska-Newton AM, Stoner L, Meyer ML. Determinants of Vascular Age: an Epidemiological Perspective. Clinical Chemistry. 2019; 65: 108–118.
[41] Germano-Soares AH, Andrade-Lima A, Menêses AL, Correia MA, Parmenter BJ, Tassitano RM, *et al*. Association of time spent in physical activities and sedentary behaviors with carotid-femoral pulse wave velocity: a systematic review and meta-analysis. Atherosclerosis. 2018; 269: 211–218.
[42] Katzmarzyk PT, Powell KE, Jakicic JM, Troiano RP, Piercy K, Tennant B. Sedentary Behavior and Health. Medicine & Science in Sports & Exercise. 2019; 51: 1227–1241.
[43] Dempsey PC, Biddle SJH, Buman MP, Chastin S, Ekelund U, Friedenreich CM, *et al*. New global guidelines on sedentary behaviour and health for adults: broadening the behavioural targets. International Journal of Behavioral Nutrition and Physical Activity. 2020; 17: 151.
[44] Abdel Azim S. Risk Factors in the Early-Stage Endometrial Cancer. Management of Endometrial Cancer. 2020; 65: 213–222.

[45] Zhang S, Gong T-T, Liu F-H, Jiang Y-T, Sun H, Ma X-X, *et al*. Global, regional, and national burden of endometrial cancer, 1990–2017: results from the global burden of disease study, 2017. Frontiers in Oncology. 2019; 9: 1440.
[46] Clark D, Colantonio LD, Min Y, Hall ME, Zhao H, Mentz RJ, *et al*. Population-Attributable Risk for Cardiovascular Disease Associated with Hypertension in Black Adults. JAMA Cardiology. 2019; 4: 1194.
[47] Cust AE, Kaaks R, Friedenreich C, Bonnet F, Laville M, Lukanova A, *et al*. Plasma Adiponectin Levels and Endometrial Cancer Risk in Pre- and Postmenopausal Women. The Journal of Clinical Endocrinology & Metabolism. 2007; 92: 255–263.
[48] Felix AS, Bower JK, Pfeiffer RM, Raman SV, Cohn DE, Sherman ME. High cardiovascular disease mortality after endometrial cancer diagnosis: Results from the Surveillance, Epidemiology, and End Results (SEER) Database. International Journal of Cancer. 2017; 140: 555–564.
[49] Campbell KL, Winters-Stone KM, Wiskemann J, May AM, Schwartz AL, Courneya KS, *et al*. Exercise Guidelines for Cancer Survivors: Consensus Statement from International Multidisciplinary Roundtable. Medicine & Science in Sports & Exercise. 2019; 51: 2375–2390.
[50] Koutoukidis DA, Lopes S, Atkins L, Croker H, Knobf MT, Lanceley A, *et al*. Use of intervention mapping to adapt a health behavior change intervention for endometrial cancer survivors: the shape-up following cancer treatment program. BMC Public Health. 2018; 18: 415.
[51] Lynch BM. Sedentary Behavior and Cancer: a Systematic Review of the Literature and Proposed Biological Mechanisms. Cancer Epidemiology Biomarkers & Prevention. 2010; 19: 2691–2709.
[52] Peterson LL, Ligibel JA. Physical Activity and Breast Cancer: an Opportunity to Improve Outcomes. Current Oncology Reports. 2018; 20: 50.
[53] Patel AV, Friedenreich CM, Moore SC, Hayes SC, Silver JK, Campbell KL, *et al*. American College of Sports Medicine Roundtable Report on Physical Activity, Sedentary Behavior, and Cancer Prevention and Control. Medicine & Science in Sports & Exercise. 2019; 51: 2391–2402.
[54] von Gruenigen VE, Waggoner SE, Frasure HE, Kavanagh MB, Janata JW, Rose PG, *et al*. Lifestyle Challenges in Endometrial Cancer Survivorship. Obstetrics & Gynecology. 2011; 117: 93–100.
[55] Piercy KL, Troiano RP. Physical Activity Guidelines for Americans from the us Department of Health and Human Services. Circulation: Cardiovascular Quality and Outcomes. 2018; 11: e005263.
[56] Piercy KL, Troiano RP, Ballard RM, Carlson SA, Fulton JE, Galuska DA, *et al*. The Physical Activity Guidelines for Americans. The Journal of the American Medical Association. 2018; 320: 2020.
[57] Herazo-Beltrán Y, Pinillos Y, Vidarte J, Crissien E, Suarez D, García R. Predictors of perceived barriers to physical activity in the general adult population: a cross-sectional study. Brazilian Journal of Physical Therapy. 2017; 21: 44–50.
[58] Baillot A, Chenail S, Polita NB, Simoneau M, Libourel M, Nazon E, *et al*. Physical activity motives, barriers, and preferences in people with obesity: A systematic review. PLoS ONE. 2021; 16: e0253114.
[59] Blanchard CM, Courneya KS, Stein K. Cancer Survivors' Adherence to Lifestyle Behavior Recommendations and Associations with Health-Related Quality of Life: Results from the American Cancer Society's SCS-II. Journal of Clinical Oncology. 2008; 26: 2198–2204.
[60] Westin SN, Sun CC, Tung CS, Lacour RA, Meyer LA, Urbauer DL, *et al*. Survivors of gynecologic malignancies: impact of treatment on health and well-being. Journal of Cancer Survivorship. 2016; 10: 261–270.
[61] Yu C, Wang T, Chang C, Liang S, Wu S, Liu C, *et al*. Healthy life styles, sleep and fatigue in endometrial cancer survivors: a cross-sectional study. Journal of Clinical Nursing. 2020; 29: 1372–1380.
[62] Kokts-Porietis RL, Elmrayed S, Brenner DR, Friedenreich CM. Obesity and mortality among endometrial cancer survivors: a systematic review and meta-analysis. Obesity Reviews. 2021; 22: e13337.
[63] Basen-Engquist K, Scruggs S, Jhingran A, Bodurka DC, Lu K, Ramondetta L, *et al*. Physical activity and obesity in endometrial cancer survivors: associations with pain, fatigue, and physical functioning. American Journal of Obstetrics and Gynecology. 2009; 200: 288.e1–288.e8.
[64] Basen-Engquist K, Carmack CL, Li Y, Brown J, Jhingran A, Hughes DC, *et al*. Social-cognitive theory predictors of exercise behavior in endometrial cancer survivors. Health Psychology. 2013; 32: 1137.
[65] Santos R, Mota J, Okely AD, Pratt M, Moreira C, Coelho-e-Silva MJ, *et al*. The independent associations of sedentary behaviour and physical activity on cardiorespiratory fitness. British Journal of Sports Medicine. 2014; 48: 1508–1512.
[66] DiPietro L, Al-Ansari SS, Biddle SJH, Borodulin K, Bull FC, Buman MP, *et al*. Advancing the global physical activity agenda: recommendations for future research by the 2020 who physical activity and sedentary behavior guidelines development group. International Journal of Behavioral Nutrition and Physical Activity. 2020; 17: 143.
[67] Zieff G, Bates LC, Kerr ZY, Moore JB, Hanson ED, Battaglini C, *et al*. Targeting sedentary behavior as a feasible health strategy during COVID-19. Translational Behavioral Medicine. 2021; 11: 826–831.
[68] Robertson MC, Lyons EJ, Song J, Cox-Martin M, Li Y, Green CE, *et al*. Change in physical activity and quality of life in endometrial cancer survivors receiving a physical activity intervention. Health and Quality of Life Outcomes. 2019; 17: 91.
[69] Basen-Engquist K, Carmack C, Brown J, Jhingran A, Baum G, Song J, *et al*. Response to an exercise intervention after endometrial cancer: Differences between obese and non-obese survivors. Gynecologic Oncology. 2014; 133: 48–55.
[70] Schwartz AR, Bartlett DB, Johnson JL, Broadwater G, Channell M, Nolte KC, *et al*. A Pilot Study of Home-Based Exercise and Personalized Nutrition Counseling Intervention in Endometrial Cancer Survivors. Frontiers in Oncology. 2021; 11: 669961.
[71] Koutoukidis DA, Beeken RJ, Lopes S, Knobf MT, Lanceley A. Attitudes, challenges and needs about diet and physical activity in endometrial cancer survivors: a qualitative study. European Journal of Cancer Care. 2017; 26: e12531.
[72] Júdice PB, Hamilton MT, Sardinha LB, Silva AM. Randomized controlled pilot of an intervention to reduce and break-up overweight/obese adults' overall sitting-time. Trials. 2015; 16: 490.
[73] Hartman YAW, Tillmans LCM, Benschop DL, Hermans ANL, Nijssen KMR, Eijsvogels TMH, *et al*. Long-Term and Acute Benefits of Reduced Sitting on Vascular Flow and Function. Medicine & Science in Sports & Exercise. 2021; 53: 341–350.
[74] Constantine GD, Kessler G, Graham S, Goldstein SR. Increased Incidence of Endometrial Cancer Following the Women's Health Initiative: an Assessment of Risk Factors. Journal of Women's Health. 2019; 28: 237–243.
[75] Lucas AR, Focht BC, Cohn DE, Buckworth J, Klatt MD. A Mindfulness-Based Lifestyle Intervention for Obese, Inactive Endometrial Cancer Survivors: a Feasibility Study. Integrative Cancer Therapies. 2017; 16: 263–275.
[76] Smits A, Lopes A, Das N, Bekkers R, Galaal K. The impact of BMI on quality of life in obese endometrial cancer survivors:

does size matter? Gynecologic Oncology. 2014; 132: 137–141.
[77] Bull FC, Al-Ansari SS, Biddle S, Borodulin K, Buman MP, Cardon G, *et al*. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. British Journal of Sports Medicine. 2020; 54: 1451–1462.
[78] Dogra S, Copeland JL, Altenburg TM, Heyland DK, Owen N, Dunstan DW. Start with reducing sedentary behavior: a stepwise approach to physical activity counseling in clinical practice. Patient Education and Counseling. 2022; 105: 1353–1361.
[79] Ligibel JA, Pierce LJ, Bender CM, Crane TE, Dieli-Conwright C, Hopkins JO, *et al*. Attention to diet, exercise, and weight in oncology care: Results of an American Society of Clinical Oncology national patient survey. Cancer. 2022. (in press)
[80] von Weichs V, Krott NR, Oettingen G. The Self-Regulation of Conformity: Mental Contrasting With Implementation Intentions (MCII). Frontiers in Psychology. 2021; 12: 546178.
[81] Clark LH, Ko EM, Kernodle A, Harris A, Moore DT, Gehrig PA, *et al*. Endometrial Cancer Survivors' Perceptions of Provider Obesity Counseling and Attempted Behavior Change: Are We Seizing the Moment?. International Journal of Gynecological Cancer. 2016; 26: 318–324.
[82] Szczuka Z, Banik A, Abraham C, Kulis E, Luszczynska A. Associations between self-efficacy and sedentary behaviour: a meta-analysis. Psychology & Health. 2021; 36: 271–289.
[83] Arbour KP, Martin Ginis KA. A randomised controlled trial of the effects of implementation intentions on women's walking behaviour. Psychology & Health. 2009; 24: 49–65.
[84] Kappes A, Oettingen G, Pak H. Mental Contrasting and the Self-Regulation of Responding to Negative Feedback. Personality and Social Psychology Bulletin. 2012; 38: 845–857.
[85] Gollwitzer PM, Sheeran P. Implementation intentions and goal achievement: A meta-analysis of effects and processes. Advances in Experimental Social Psychology. 2006; 38: 69–119.