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Building a multiple modality, theory-based physical activity intervention: The development of Cardi*ACTION!*

Paul A. Estabrooks[1,2], **Russ E. Glasgow**[2], **Stan Xu**[2], **David A. Dzewaltowski**[3], **Rebecca E. Lee**[4], **Deborah Thomas**[5], **Fabio A. Almeida**[1], **Amy N. Thayer**[1], and **Renae L. Smith-Ray**[6]

[1]Department of Human Nutrition, Foods, & Exercise, Translational Obesity Research Program, Virginia Polytechnic Institute and State University

[2]Institute for Health Research, Kaiser Permanente Colorado

[3]Department of Kinesiology, Kansas State University

[4]Health & Human Performance, Texas Obesity Research Center, University of Houston

[5]Department of Geography & Environmental Sciences, University of Colorado Denver

[6]Center for Research on Health and Aging, University of Illinois Chicago

Abstract

Objectives—Despite the widely acknowledged benefits of regular physical activity (PA), specific goals for increased population levels of PA, and strongly recommended strategies to promote PA, there is no evidence suggesting that the prevalence of PA is improving. If PA intervention research is to be improved, theory should be used as the basis for intervention development, participant context or environment should be considered in the process, and intervention characteristics that will heighten the likelihood of translation into practice should be implemented (e.g., ease of implementation, low human resource costs). The purpose of this paper is to describe the implementation of the aforementioned concepts within the intervention development process associated with CardiACTION an ongoing randomized 2 × 2 factorial trial.

Methods—The Ecological Model of Physical Activity integrated with Protection Motivation Theory was used to inform the design of the interventions. This integrated model was selected to allow for the development of theory-based individual, environmental, and individually + environmentally targeted physical activity interventions. All intervention strategies were matched to proposed mediators of behavior change. Strategies were then matched to the most appropriate interactive technology (i.e., interactive computer session, automated telephone counseling, and tailored mailings) delivery channel.

Conclusions—The potential implications of this study include determining the independent and combined influence of individual and environment mechanisms of behavior change on intervention effectiveness. In addition, all intervention models are developed to be scalable and disseminable to a broad audience at a low cost.

Address Correspondence to: Paul Estabrooks, Translational Obesity Research Program, Virginia Tech, 1 Riverside Circle SW, Suite #104, Roanoke, VA, 24016 estabrkp@vt.edu.

Despite the widely acknowledged benefits of regular physical activity (PA), specific goals for increased population levels of PA, and strongly recommended strategies to promote PA, there is no evidence suggesting that the population prevalence of PA is improving (Haskell et al., 2007). The lack of change in population rates of PA may be due to a number of issues. First, few interventions are based on theoretical models that provide an understanding of the causal mechanisms of intervention effectiveness (Brug, Oenema, & Ferreira, 2005). Second, intervention studies that have used theoretical models in their development have primarily used social-psychological theories as their basis with little attention to potential contextual or environmental influences. Third, more research is needed to identify the aspects of PA interventions that enable translation of the intervention into practice. Thus, if PA intervention research is to be improved, theory should be used as the basis for intervention development, participant context or environment should be considered in the process, and intervention characteristics that will heighten the likelihood of translation into practice should be implemented (Sussman & Sussman, 2001).

This paper describes Cardi*ACTION*, a randomized 2 × 2 factorial study of theory-based individual and environmental PA interventions designed to influence the hypothesized mediators of intervention effectiveness. The purpose of this study was to assess whether PA behavior change is more likely when the participants' social-cognitive beliefs are intervened upon (individual intervention), when access is provided to environmental resources for PA (environmental intervention), or when both social-cognitive beliefs and access to environmental PA resources are manipulated (combination intervention including individual and environmental intervention components). Each of these three interventions was developed specifically for this study and will be compared to a control group that is matched on contact channels and modalities but targets healthy eating. A second purpose of this study is to explore whether individual or environmental factors mediate PA behavior change. The target group for the trial was healthcare patients who had been referred for a treadmill cardiovascular stress test—but do not present abnormal ECG or chest pain during testing. This population is at heightened risk for mortality due to the increased prevalence of abnormal heart rate recovery and could benefit substantially from increased PA (Borresen & Lambert, 2008). Participants were recruited into the study immediately following the treadmill stress test. At that time, the participants completed an initial computer-based screening to determine eligibility. Eligible patients were those who did not report meeting the recommended guidelines for physical activity (i.e., <150 minutes of moderate PA per week), spoke English, did not currently have a fitness facility membership, and had a telephone. One week later participants returned to the clinic at which time they were randomized to one of the four interventions and, immediately following randomization, completed an interactive CD-ROM specific to their intervention. The first set of baseline measures was completed at this time which marked the beginning of each intervention.

During the following 6 months participants received frequent contacts delivered via interactive voice response (IVR) automated telephone calls and mailings, each providing intervention-specific information to encourage and facilitate PA or healthful eating behavior change. See Figure 1 for a complete guide to intervention contact type and frequency. Participants were followed for a total of 18 months and measures were completed at baseline, 6-, 12-, and 18-months. Although recruitment was complete, data collection was underway at the time of publication.

The intervention strategies were designed using a systems-based research practice partnership. That is, a working partnership was established between the research team, key stakeholders at the organizational level, and clinical staff in order to implement this intervention within the existing organizational structure. There was an explicit focus on characteristics of the intervention that would enhance the likelihood of translation into

practice (e.g., Can the intervention feasibly be implemented across the entire organization?; Does the intervention fit within the flow of patient care without adding much additional burden?; Estabrooks & Glasgow, 2006). The specific purposes of this manuscript are to (1) provide a brief description of, and rationale for, the theoretical model used as the basis for intervention development, (2) describe the operationalization of theory-based strategies that target specific potential mediators of behavior change, (3) highlight the proposed method of determining mediation, and (4) outline the implications of this study in the broader context of PA promotion research.

The outcome of this experimental design will determine if the individual, environment, or a combination of these two strategies was most effective at influencing PA. It was hypothesized that intervention effectiveness may be mediated by individual psychological variables (Figure 2). Specifically, the effectiveness of psychological skill interventions is based on influencing Protection Motivation Theory (PMT; Rogers, 1975;1983) variables, whereas the environmental interventions may directly influence PA without change in PMT variables. Specifically, it is hypothesized that the *Individual* participants' changes in PA will be primarily mediated by the PMT variables. It is also hypothesized that changes in PA for the *Environmental* participants will be partially mediated by perceptions of accessibility (Humpel, Owen, & Leslie, 2002); however it is also hypothesized based on the Ecological Model of Physical Activity (EMPA; Spence & Lee, 2003;Sallis et al., 2006) that this intervention will have a direct effect that is not mediated by personal cognition. Finally, we hypothesize that the combination condition participants will increase PA to the greatest extent and that the effect will be mediated by both categories of PMT and environmental constructs.

Theory Selection

A common lay belief is that being physically active is completely in the domain of individual choice and if an individual just had the “willpower” to stick with a lifestyle change, they too could be more active. Yet, this does not acknowledge the fact that equal opportunities to be physically active may not be available across all subgroups of the population (Estabrooks, Gyurcsik, & Lee, 2003; Sallis et al.). Although an individual must have the physical capacity to be active, actually adopting and maintaining a physically active lifestyle may have as much to do with contextual factors as it does with individual beliefs, attitudes, knowledge, or self-regulation skills (Brofenbrenner, 1989; Humpel et al.; Sallis et al.; Spence & Lee, 2003). For example, Sallis and colleagues (2006) outlined an ecological model that included the focus on four domains of active living (i.e., Active Recreation, Active Transport, Occupational Activities, & Household Activities). In addition to intrapersonal factors like those described above, the model included specific focus on information environments, recreational environments, and access to resources, among others, to support recreational PA.

The identification of an appropriate theoretical model for Cardi*ACTION* intervention development was based on three broad needs. First, the model needed to address potential environmental factors that could influence behavior. Second, it had to allow for potential individual self-regulation skill factors that could influence behavior. Third, it should integrate environmental factors with the specific risk related social cognitive variables that could be salient for patients referred for cardiac stress testing. In addition to its focus on physical activity, the EMPA (Spence & Lee, 2003) meet each of the three requirements and was selected to frame and inform intervention development.

The Ecological Model of Physical Activity

The EMPA provides a theoretical framework ripe for intervention development that can address the interplay between an individual and the environment (Brofenbrenner, 1989). The model has the advantage of incorporating micro- to macro-level factors associated with physical activity (Spence & Lee, 2003) accounting for its systemic and dynamic nature. The theory highlights that environmental influences on PA can be described in terms of micro (day-to-day behavioral settings), meso (connections to micro-environments), exo (links to other micro-environments that do not include the individual), and macro (the broader social context) levels (Spence & Lee; Figure 3). The EMPA may be more useful both as a model to investigate how the multiple factors interact and influence PA—and to guide the development of strategies to effectively change behavior.

Support for the EMPA hypothesis that micro and meso environmental changes can influence PA can be gleaned from The Task Force on Community Preventive Services (Kahn et al., 2002). A number of studies have demonstrated that PA can be increased, or risk factors reduced, by providing increased access to resources for PA (i.e., adding micro environments) (Bertera, 1993; Blair, Piserchia, Wilbur, & Crowder, 1986; Brownson et al., 1996; Heirich, Foote, Erfurt, & Konopka, 1993; Henritze, Brammell, & McGloin, 1992; Humpel et al.; King, Carl, Birkel, & Haskell, 1988; Larsen & Simons, 1993; Linenger, Chesson, & Nice, 1991; Ostwald, 1989). Of these studies, most were work site health promotion studies that included multifaceted initiatives to change employee behavior (Bertera; Blair et al.; Heirich et al.; Henritze et al.; King et al.; Larsen & Simons; Ostwald). Interestingly, many of these studies did not manipulate the physical environments that they studied, but rather, implemented social PA programming, staffing at pre-existing fitness rooms, and one-on-one counseling to increase the use of already existing resources for PA (Bertera; Blair et al.; Heirich et al.; King et al.; Ostwald). Two studies did include environmental manipulation that differed between the intervention and control conditions (Brownson et al.; Linenger et al.). These studies added walking paths and bicycle lanes at the intervention sites. In each of these studies increased access to physical resources improved in PA, risk, and fitness outcomes of the individuals exposed to the environmental changes. Unfortunately, each of these studies also included the implementation of social and individual level strategies concurrently with the environmental changes leaving unclear how each if these components independently influenced PA.

EMPA also posits that environmental effects on PA will be largely mediated by psychological variables. However, rather than explicitly operationalizing what psychological variables are most appropriate, it allows for a tailoring of individual level theory to the specific population being examined. Our target population may enter stress testing with an elevated perception of risk of injury or death, thus providing some threat appraisal that could be motivational in making personal behavior changes (Plotnikoff & Higginbotham, 1998). The natural occurrence of varying perceptions of risk in this population led our research team to identify a psychological theory that included threat appraisal and coping strategies that could be used to take advantage of the potential heightened motivation for behavior change within this population (Plotnikoff & Higginbotham, 1998).

Protection Motivation Theory

PMT proposes that decisions to engage in healthy versus unhealthy behaviors (i.e., choosing to be physically active or choosing to replace activity time with a sedentary alternative like watching TV) are thought to be influenced by two primary cognitive processes, threat and coping appraisals (Figure 4) (Rogers, 1975,1983). Threat appraisal is the result of an individual judging the intrinsic and extrinsic rewards associated with the unhealthy alternative (e.g., watching TV at home rather than completing planned exercise) less her/his

perceptions of the severity of the threat and her/his perceptions of vulnerability to the threat. The theory suggests that as perceptions of vulnerability and severity increase, the likelihood of participating in the unhealthy alternative decreases. However, the likelihood of continuing unhealthy behavior is increased by the perceived intrinsic rewards (e.g., pleasure) and extrinsic rewards for that behavior (e.g., approval by peers; Rogers, 1983).

Coping appraisal is the result of an individual's perception of response efficacy (i.e., will physical activity reduce the individual's cardiovascular risk) and self efficacy (i.e., the belief in one's personal ability to complete physical activity) when considering the perceived costs of completing the adaptive response (i.e., physical activity). As response efficacy and self-efficacy increase, so does the likelihood of engaging in the recommended preventive behavior. However, is decreased by the perceived response costs (e.g., loss of pleasure; Rogers, 1983).

PMT hypothesizes that initial changes in behavior will occur when both threat and coping appraisals are high. Two meta-analyses investigating the utility of PMT in more than 20 health behaviors, including PA supported the utility of the theory for the prediction of behavior change (Floyd, Prentice-Dunn, & Rogers, 2000; Milne, Sheeran, & Orbell, 2000). Although the utility of PMT is promising, correlational (Plotnikoff & Higginbotham, 1998) or hypothetical essay manipulation (Wurtele & Maddux, 1987) studies dominate the literature and, to date, no study has attempted to use PMT as the basis for a PA intervention. The theory was selected for this study because of the dual focus on threat and coping appraisals. Stress test patients, even those whose test results are negative, may be in a context where risks of an unwanted health outcome are naturally elevated (i.e., having chest pains that lead to the referral for stress testing). The propositions of PMT suggest that this population may respond to an intervention that targets both threat and coping appraisal.

Developing Theory-Based and Technology-Matched Intervention Strategies

The combined use of the EMPA and PMT provides an opportunity to develop a number of individual and environmental intervention strategies. For the environmental strategies, we identified increasing an individual's micro-environmental context to include a convenient PA resource (i.e., providing membership to a fitness center) and increasing awareness of environmental PA resources relative to a specific meso environment (i.e., the path to and from work) and related micro-environments (i.e., at home, at work, the surrounding neighborhoods) as the basis for environmental manipulations. For the individual strategies, we targeted PMT constructs as potential meditational targets for intervention development. Table 1 provides a list of proposed behavioral mediators of PA change identified for Cardi*ACTION* and related strategies used within the interventions.

Technological Structure of Cardi*ACTION*

The method of delivering intervention strategies was determined by a research practice partnership that included representation from multiple levels of organizational leaders and care providers associated with the local health care system and stress test center targeted for intervention (Estabrooks & Glasgow, 2006). These partners agreed that any intervention that could potentially be effective and sustainable would require multiple contacts with patients but have a low level of impact on systemic personnel resources. Thus, computer-assisted delivery was targeted as the primary mode of intervention.

A brief review of computer assisted delivery to support behavior change includes promising avenues for the use of interactive computer sessions, automated telephone counseling, and tailored mailings (Kreuter, Strecher, & Glassman, 1999; Piette et al., 2000; Prochaska, Velicer, Fava, Rossi, & Tsoh, 2001). Although the long-term benefits of such interactive

technologies are still debatable, it is clear that well designed interactive programs can help people achieve health behavior changes in areas such as smoking cessation, eating patterns, PA levels, improving depressed mood, and adhering to medical regimens (Brug, Campbell, & van Assema, 1999; Estabrooks & Smith-Ray, 2008; Norman et al., 2007; McDaniel, Benson, Roesener, & Martindale, 2005; Piette et al.). Further, programs that engage users over a series of `sessions' or over a period of time produce superior outcomes (Gustafson et al., 2001; Tate, Wing, & Winett, 2001).

Remaining questions concerning interactive health technology applications for behavior change include how to reach and engage large and representative portions of the population at risk, and how to combine different technologies to best use the respective strengths and minimize limitations of each modality (Curry, 2007; Glasgow, 2007). Various technological components were used in order to deliver a tailored message addressing each of the proposed mediators of behavior change. The components of each intervention developed within the project were matched on technology type and contact frequency. Specifically, all participants completed an initial interactive computer session which was followed by alternating tailored mailings (four) and interactive voice response (IVR) automated telephone counseling sessions (three) over a six-month period (Figure 1). Finally, theory-based strategies were matched to an appropriate interactive technology delivery channel(s).

This process resulted in the development of three intervention conditions to compare to a control group. The first intervention, *Individual*, was based on PMT alone and included strategies that aligned with building self-regulation skills to influence the social cognitive variables outlined in Figure 4. The second intervention, *Environmental*, was based on micro and meso environmental changes alone and included strategies that aligned with increasing PA resource accessibility, awareness, and use. The third intervention, *Combination*, was based upon both self-regulation skills and environmental influences and included all strategies used in the *Individual* and *Environmental* interventions. A fourth intervention, matched on technology modalities and frequency of contact, targeted improvements in healthful eating and served as a control condition. We will focus on the *Individual* and *Environmental* interventions to illustrate the differences in content.

Interactive Computer Sessions—The interactive computer session allowed the use of audio information, visual graphics, text, video, and the use of familiar models and locations. Both the *Individual* and *Environmental* interventions began with an opening message about the importance of physical activity to achieving good health, filmed in the local treadmill center, from the Chief of Cardiology. The environmental and individual interactive computer sessions had similar features such as personal messages from the KP Chief of Cardiology and a Behavioral Coach. As part of the research team, the Chief of Cardiology was involved during the development phase and contributed to content on risk and severity messages. The research team then drafted the scripts for all interactive content delivered by the Behavioral Coach and the Chief of Cardiology to align messages with appropriate proposed mediators.

Within the context of Protection Motivation Theory, participants receiving the *Individual* intervention completed a variety of interactive activities throughout the session highlighting behavioral mediators. *Intrinsic and extrinsic rewards* of inactivity were identified by asking the participant to select two to three personal rewards received from sedentary behaviors. These rewards were then aligned with physically active alternatives (e.g., A participant who identifies a reward of being more productive by working late receives a message that “Regular PA increases productivity at work and reduces the number of sick days. Try a 20-minute walk in the afternoon at work to help improve your productivity”). *Perceptions of severity* (e.g., “not managing your condition could lead to painful heart attacks, leaving you

debilitated or worse, dead) and *vulnerability* (e.g., “people who are referred to stress testing, even if they have a negative test, are at a higher risk of mortality and you are at further risk because of your current level of PA”) are targeted by the message delivered by the Chief of Cardiology, but also by that of a Behavioral Coach who guides the participant through the computer session.

Additionally, participants were prompted to complete a brief assessment of current levels of PA, which was used to offer feedback and assist the participant with setting goals. *Response Efficacy* and *Self Efficacy* were addressed, respectively, by asking participants to select specific benefits of PA related to risk reduction and providing verbal persuasion from the Behavioral Coach. *Perceived costs* of PA were highlighted by prompting participants to select two to three obstacles that are most likely to arise when they tried to increase PA and then providing a menu of potential strategies to overcome each barrier. The computer session concluded with a summary of the participant provided information identifying motives, barriers, strategies to overcome barriers, cognitive restructuring, and a specific goal for increased PA within a printed personal action plan. Finally, single item indicators of the primary proposed PMT mediators were assessed to allow for tailoring of the subsequent automated mailing.

The computer session for the *Environmental* intervention participants included messages from the Chief of Cardiology and Behavioral Coach related to the presence of environmental resources for PA in one's community. A user-friendly mapping (geographic information systems; GIS) interface was developed to input the participants' home and work addresses and guide them in the selection of a fitness facility that was near their home, work, or on the path in between. Participants could browse facilities by location or by amenities. At the completion of the session a participant selected a facility and the computer printed out a voucher for a 12 month membership for one of the 52 possible facilities. Address data were stored and used for the subsequent automated mailing.

Automated Mailings—For participants receiving the *Individual* intervention, *self efficacy* and *response efficacy* were a recurring theme. In addition to self efficacy and response efficacy, other PMT constructs were selectively highlighted across letters so that each of the PMT constructs were addressed by the last newsletter. Each letter featured a targeted message that addressed the participant's *self-efficacy* rating indicated during the previous week's contact. Each newsletter also included a message from the Chief of Cardiology. These messages were individually tailored using *severity* and *vulnerability* scores collected at baseline and discussed topics such as heart disease as a consequence of an inactive lifestyle. Finally, each newsletter included a message based on vicarious learning (Sarah's or Joe's story based on participant gender). The story line of these messages was tailored based on the participant's current state of goal achievement (i.e., if the participant did not achieve his/her goal, Joe/Sarah also encounter obstacles), thus many iterations of the story were created with each ultimately demonstrating successful behavior change.

Environmental intervention participants received newsletters that highlighted the availability of resources as illustrated by a detailed street map that included the participant's chosen recreation center, home, and work. Other tailored messages provided practical information such as program/facility details about the participant's chosen recreation center. In addition, a GIS database was developed that included locations and brief descriptions of local parks, trails, and fitness facilities for the entire region so that subsequent mailings could be produced that included maps of trails and parks close to the participant's home and work with driving/walking directions. As with the *Individual* intervention newsletters, each *Environmental* intervention newsletter featured a brief introduction from the Chief of

Cardiology and a message from the Behavioral Coach. All messages and information focused on physical activity resources found in the community, home, or work environment.

Interactive Voice Response—Automated telephone messages were delivered using IVR technology to bridge gaps between mailings. The intent was to minimize elapsed time between contacts as well as to vary the mode of contact in order to avoid redundancy and maintain participants' interest. IVR contacts also offer advantages of real-time data collection, active outreach to participants, and a method to track continued engagement of the participant. Each IVR call was narrated by the Behavioral Coach. All participants were prompted to confirm receipt of the newsletter, answer questions regarding their current rates of PA, and respond to the single item mediator questions on each call.

Participants in the *Individual* intervention were queried on whether they were meeting their PA goals; those who indicated goal achievement were congratulated and led through the steps necessary to create a new personal action plan that allowed them to either maintain or further increase activity. Participants who indicated that they had not reached their goals received tailored messages based on their most recent responses on the measures of *risk severity* & *susceptibility* and *response* & *self-efficacy*. The three remaining IVR calls were structured similarly, resulted in a new personal action plan, and provided information for subsequent tailored mailings. Participants in the *Environmental* intervention heard a message describing opportunities for PA at home (e.g., details about different types of home exercise equipment), at work (e.g., the stairs provide a good place for activity), and in the community (e.g., school grounds are good places for activity). Participants were also asked to confirm their facility choice and to indicate if they had used their voucher.

Testing for Mediation

Traditionally, mediation has been tested following a series of models described by Baron and Kenny (Baron & Kenny, 1986) and more recently through a direct statistical test of mediation (MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002). Following the examination of intervention group differences, the estimation methods for the mediated effect and its standard error are illustrated using the following three regression models: Model 1: $Y=\beta_1+\tau X+\varepsilon_1$; Model 2: $Y=\beta_2+\tau' X+\beta M+\varepsilon_2$; Model 3: $M=\beta_3+\alpha X+\varepsilon_3$. The outcome variable Y is regressed on the independent variable X using Model 1. The outcome variable Y is regressed on the independent variable X (a group indicator variable) and the mediating variable M using the model (Model 2). This is a test of the intervention effect in concert with the mediator effect. The mediating variable M is regressed on the independent variable X (Model 3).

The total effect of regressing Y on X is coefficient in the regression model 1, τ. The total effect can be expressed as: $\tau = \tau' + (\tau - \tau')$ where τ' is sometimes referred to as the non-mediated or the direct effect and $(\tau - \tau')$ is known as the indirect or mediated effect. An important statistical challenge in mediation analysis lies in the estimation of the standard error of the mediated effect. Here we estimate the standard error using the equivalence: $\tau - \tau' = \alpha\beta$. When *a* and *b* are estimators for α and β, respectively. We will use Sobel's (1990) recommendation of the multivariate delta method estimator of the variance of *ab* ($S_{ab}^2 = S_a^2 b^2 + S_b^2 a^2$).

In this study, the total effect can be described as the intervention's influence on PA through processes that are both accounted for and not accounted for by hypothesized mediators. The indirect effect is the amount of the intervention's effect that can be accounted for by hypothesized mediators. An important theoretical issue that will be addressed by this study

is whether the environmental interventions can have a direct effect on PA independent of psychological mediation (Spence & Lee, 2003).

Study Implications

Cardi*ACTION* provides an opportunity to advance the field of PA promotion both theoretically and practically. First, its experimental manipulation of proposed mediators of PA change presents an opportunity to determine the causality of individual self-regulation strategies and environmental strategies for behavior change. Second, by manipulating both environmental and individual mechanisms of behavior change including assessing constructs from PMT, the study will provide insight into the relative importance of psychological mediators of PA interventions. Third, it applies different methods of interactive technology matched to theoretically-derived strategies that should result in a scalable intervention with the potential for broad reach and applicability.

To date, much work has been done to determine the relationships between PA and personal, social, or environmental variables (Bauman, Sallis, Dzewaltowski, & Owen, 2002; Carron, Hausenblas, & Mack, 1996; Dishman & Sallis, 1994; Hausenblas, Carron, & Mack, 1997). Consistent and moderate to large relationships have been identified, in meta-analytic reviews, between PA and the social environment, control beliefs (including self-efficacy), and expected outcomes from regular PA (Bauman et al.; Carron et al.; Hausenblas et al.). However, these findings are based primarily on non-experimental designs that do not provide compelling data to identify these variables as causal determinants. Cardi*ACTION* moves beyond the identification of correlates of PA to the identification of the causal determinants. Assessments of individual (i.e., through the assessment of PMT variables) and environmental (i.e., through environmental access and awareness) mechanisms of change will be completed and, as described in our approach to mediation, analyzed to determine why the intervention strategies were or were not effective.

Finally, this project was designed to increase the likelihood of dissemination of the intervention to patients who are inactive or insufficiently active. The intervention design was developed through a collaborative process with the clinical personnel who were responsible for the patient population and understood the flow of patient care, organizational structure and values, and the resource scarcity for PA promotion following cardiac stress testing. This resulted in an intervention that could be delivered with a low level of staff monitoring, using existing resources reflective of health care settings (i.e., computer, printer, and automated telephone system), and reach all eligible patients with an extended visit of 20 minutes at the completion of their stress test. These features, especially those involving organizational resources, increase the likelihood of sustaining the program (Rogers, 2002). Further, the provision of access to local fitness facilities has demonstrated cost effectiveness within managed care settings and has been sustained across a number of settings without extramural grant support (Nguyen et al., 2008). If effective, the model should also have applicability to other patient populations that encounter natural elevations in threat appraisal (e.g., recent diagnoses of pre-diabetes).

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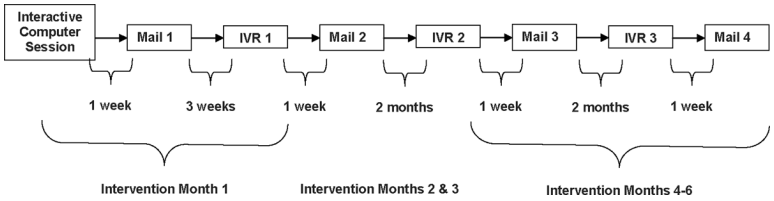

Figure 1.
Structure of Cardi*ACTION* interventions

Figure 2.
Proposed mediators of physical activity behavior change for each of the three intervention study arms

Figure 3.
Adapted Ecological Model of Physical Activity

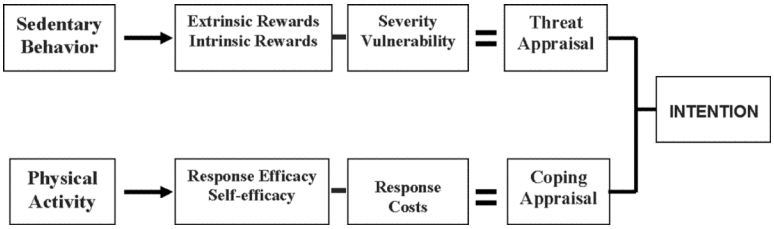

Figure 4.
Protection Motivation Theory

Table 1

Matching specific intervention strategies to proposed theoretical mediators of physical activity change.

Proposed Mediator	Intervention Strategies
Access to Resources	• Provide membership to fitness facility within participant meso environment (i.e., path to and from work) or other convenient location
Awareness of existing resources	• Identify local parks and trails in close proximity to primary micro environments (i.e., home & work) • Review possible home exercise resources that are affordable or exist within the home • Identify possible resources at the workplace to support PA (e.g., onsite exercise room or programs)
Perceived severity	• Physician, health educator, or peer model delivered information on potential of physical inactivity to have substantial negative outcomes related to: ○ Personal health (e.g., continued inactivity could lead to death) ○ Social relationships (e.g., a debilitating heart attack will leave one's family financially compromised) ○ Quality of life (e.g., loss of independence and control).
Perceived vulnerability	• Physician, health educator, or peer model delivered information on the personal susceptibility of the potential of unwanted health, social, and quality of life outcomes as a result of continued physical inactivity. ○ Include information on samples of patients similar to the participant (e.g.. people who pass the stress test are still at high risk for mortality) ○ Dismissing negative stress test as the sole indicator of personal risk reduction.
Rewards for Inactivity	• Cognitive restructuring ○ Identify rewards for competing behaviors that are physically inactive (e.g.. stress relief, relaxation) ○ Allow individuals the option of selecting a number of physical activities that also produce the same rewards (e.g., stress relief and relaxation) ○ Make reward link for physical activity explicit.
Self-efficacy	• Verbal persuasion • Vicarious learning • Feedback on performance success • Barrier identification and resolution • Graded physical activity goals
Response-efficacy	• Physician, health educator, or peer model delivered information on the risk avoidance benefits of PA related to: ○ Personal health (e.g., regular PA reduce risk of premature death) ○ Social relationships (e.g., regular PA can reduce the risk of a debilitating heart attack and allow one to continue to provide for his/her family) ○ Quality of life (e.g., regular PA will alleviate the risk of losing of independence and control).
Response-cost	• Physician, health educator, or peer model delivered information on the: ○ Likely barriers to regular PA that will be encountered.

Proposed Mediator	Intervention Strategies
	○ Effective strategies for overcoming these barriers.
Intention	• Assistance to develop appropriate goals for PA • Facilitated personal action planning • Goal setting and feedback loop