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The Effectiveness of Lifestyle Physical Activity Interventions to Reduce Cardiovascular Disease

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Abstract

Lifestyle interventions have evolved from proof of concept pilot studies to efficacy and effectiveness studies and have now moved toward translation and dissemination studies because of their demonstrated ability to improve cardiovascular diseases (CVD) outcomes including blood pressure. When combined with diet, they also have demonstrated the ability to normalize blood glucose and help to regulate weight. This review highlights the converging lines of evidence that led to lifestyle physical activity interventions beginning with early epidemiology studies and provides evidence for the efficacy and effectiveness of lifestyle interventions. However, if lifestyle interventions are to play a role in preventing CVD and improving CVD outcomes, their use must be more widespread. This will require translational and dissemination research in order to understand how to move into real world settings. Successful examples of translational studies will be highlighted and issues related to theoretical and practical issues as well as capacity building will be discussed. Building bridges between research and practice must be done if lifestyle interventions are to deliver on their public health promise.

Keywords

effectiveness; dissemination; lifestyle physical activity; efficacy; translational studies

I. Introduction

A lifestyle intervention is likely to mean something different to a patient, nurse practitioner, health educator or physician. As a researcher of lifestyle physical activity interventions, this has a distinctive meaning that differs from the broader category of lifestyle interventions[1] that might include smoking prevention or cessation; specific dietary targets such as reduced calories, reduced calories from fat, increased fruit and vegetable consumption, increased whole grain consumption; or, stress reduction to name only a few. For the purpose of this review, the focus will mainly be on lifestyle physical activity interventions, though readers will later see the necessity of combining diet and physical activity to improve a variety of cardiovascular disease (CVD) outcomes. In previous reviews, lifestyle physical activity was defined as "… the daily accumulation of at least 30 minutes of self-selected activities, which includes all leisure, occupational, or household activities that are at least moderate to vigorous in their intensity and could be planned or unplanned activities that are part of everyday life." (p.399)[2]

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There are several crucial words in this definition that identify the roots of lifestyle physical activity interventions, and in this review, these will be examined to better understand the evolution of lifestyle physical activity research including how past research has led to efficacy, effectiveness and translational studies, and finally to a discussion of how dissemination efforts could lead to widespread use and further topics for research. The major question to be answered in this review is whether lifestyle physical activity interventions are effective in reducing CVD, and the answer is likely to depend on whether one is examining selected populations as in efficacy studies, or populations where the test is intended to be more generalizable, such as effectiveness, translation and dissemination studies. For example, lifestyle physical activity interventions may improve the risk of developing CVD by improving metabolic risk factors in efficacy studies where the intervention is tightly controlled but it is also important to ask whether these interventions are generalizable to other populations, settings, and delivery methods and whether they can be effectively translated and disseminated to the populations that need them. This review will explore some of the history of lifestyle physical activity interventions; discuss the how early efficacy studies demonstrated improvements in CVD; and, show how effectiveness and translational studies provide evidence those improvements in CVD might be generalizable to larger populations. Finally, there are numerous issues related to dissemination of lifestyle physical activity interventions that remain to be studied and better understood if they are to have a major public health impact on preventing or improving CVD outcomes.

II. A Brief History of Lifestyle Physical Activity Interventions

The roots of lifestyle physical activity interventions are found in crucial words contained within the definition of lifestyle physical activity including, leisure, occupational, and household activities and accumulation. When the evolution of lifestyle physical activity interventions is examined, it is this author's opinion, that four converging lines of research were necessary before the study of lifestyle physical activity could emerge as an intervention strategy to increase physical activity. The first of the four areas include epidemiology studies of all types of physical activity and the relation to reduced cardiovascular morbidity and mortality.[3] Epidemiology studies of adverse effects of physical inactivity, particularly those that helped to establish physical inactivity as a major risk factor for cardiovascular disease, are also included in these.[4] Second, the early research on the role of incorporating lifestyle physical activity into weight loss studies to improve adherence played a major role of expanding the study of lifestyle physical activity to sedentary populations that were not necessarily overweight or obese, and also to populations with chronic disease such as those with high blood pressure or diabetes.[5] Third, early studies on the effects of accumulating physical activity and comparisons of the effects on markers of CVD suggested that markers of cardiovascular disease, such as high blood pressure, could be improved by accumulating shorter bouts of moderate to vigorous physical activity.[6,7] Finally studies of home-based exercise demonstrated that one can perform exercise at home as well as in a gym or fitness center suggested that activities could take place in home environments and that this might make exercise more convenient and improve adherence.8 The major highlights of each of the lines of research will be examined. These highlights will be not be exhaustive and readers wanting more information on these lines of research should refer to in-depth reviews available elsewhere.3,9-13 In this review, the contributions of multiple risk factor community interventions (e.g., Stanford Five City Project, Minnesota Heart Health, and Pawtucket Heart Health) are acknowledged for informing methods, intervention and evaluation strategies they also will not be covered here since extensive reviews of these are available elsewhere.[14-18]

Epidemiology studies established the link between physical activity and CVD

Epidemiology studies of the effects of physical activity on heart disease began with the early landmark studies of Jeremy Morris in 1953. Dr. Morris and his colleagues first studied 31,000 London transport workers and found that active conductors who performed physical activity by going up and down stairs on double decker buses were 30% less likely to have a coronary episode than peers who job was to sit and drive the bus.[19] This finding was repeated in railroad workers,[20] postal service employees,[21] and longshoremen.[22,23] This finding was equally true for leisure time physical activity[24-26] and more recent reviews have found that habitual activity of all types has an inverse risk on CHD events in both men and women.[12]

In studies that included subpopulations that were habitually sedentary or inactive, risk for CHD is consistently higher than in individuals that report moderate or higher amounts of activity. A 1987 review by Powell and colleagues4 confirmed that a sedentary lifestyle was an independent risk factor for coronary heart disease and the most recent report summarizing the studies of physical inactivity and CVD confirms that individuals who report moderate amounts of physical activity have a 20% lower risk of having a coronary event than those who are inactive and those with even higher amounts of activity have a 30% lower risk.[12] In 1992, the American Heart Association (AHA) identified physical inactivity as the 4th major risk factor for cardiovascular disease.[27] The first three identified were smoking, high blood pressure and high blood cholesterol.

These epidemiology studies established that all types of physical activity could reduce risk of developing CVD, that physical inactivity was a major risk factor for developing CVD. From these came the early recommendations for exercise and physical activity from the AHA, National Institutes of Health (NIH) American College of Sports Medicine (ACSM) and Centers for Disease Control and Prevention.[28-30] Exercise and physical activity then became an important risk factor to prescribe in order to prevent CVD.

The suggestion of lifestyle physical activity approaches as an alternative to vigorous exercise training

In 1980, Drs. Brownell and Stunkard suggested a lifestyle physical activity approach as an alternative to high intensity aerobic exercise.[5] This suggestion was the result of a 1979 review of the published obesity literature by Drs. Wing and Jeffrey, showing that exercise had only been included in less than10% of weight control studies and that adherence to vigorous aerobic training programs was very low.[31] In their chapter, “Physical Activity in the Control of Obesity,” Brownell and Stunkard went on to say that substituting physical activity behaviors that included walking for brief errands instead of riding in a car, using stairs instead of taking an elevator could increase caloric expenditure as much as a regular aerobic exercise program. They also went on to suggest that these small changes to expend more energy might be better maintained because they were easier to incorporate into one’s daily life.[32]

These ideas were demonstrated a short-time later in a small randomized trial of overweight children (n=37) that were randomly assigned to one of four treatment groups: 1) diet plus lifestyle program; 2) diet plus aerobic program; lifestyle alone; or, 4) aerobic program alone.[33] Using an exercise point system similar to one of the first developed by Taylor and colleagues, 34 children were expected to expend an extra 240 calories per day and work up to expending 500 calories per day during a two month treatment. Children in the programmed aerobic group were expected to expend all of their extra calories at one time and children in the lifestyle group were allowed to earn their total points by breaking up common childhood physical activities over the course of the day. At the beginning of the trial, children were 34 to 41% overweight. At the end of the two month treatment, all groups had lost weight and were now 33 to 29% overweight and they continued to lose weight at a 6 month time point. At the 17 month follow-

up the children randomized to the lifestyle physical activity group had less weight regain than children who had been assigned to the aerobic exercise condition. In addition to changes in weight, fitness was also measured. At the end of two months, the fitness improvements were greater in the programmed aerobic exercise but at six months the fitness improvements were equivalent for the lifestyle and programmed aerobic. The investigators speculated that the equivalence was likely due to the lower adherence in the programmed aerobic exercise groups and that the lifestyle program was easier for overweight children to maintain.

A longer term follow-up study by Epstein and colleagues replicated the results of this first small study and included a calisthenics exercise group to control for the nonspecific effects of being in a group.[35] As in the first study, all groups had equivalent amounts of weight loss at 2, 6 and 12 months but at the end of 24 months, only those children assigned to the lifestyle group had maintained their weight loss.

These studies provide some of the first published experimental evidence that a lifestyle physical activity approach might be a useful alternative for helping individuals increase physical activity as well as produce modest improvements in weight loss and fitness.[36] In addition, these studies provided some support for the idea that accumulating physical activity might lead to greater adherence and increased caloric expenditure.

Studies on the Health Effects of Accumulating Physical Activity

At about the same time as the Epstein studies were being published, the first published study on the physiological effects of splitting up endurance runs was being published in the Japanese Journal of Physical Education.[6] This study examined the effects of four different exercise training conditions on oxygen uptake and high density lipoprotein (HDL) cholesterol over a period of 10 weeks. In this study, participants were randomly assigned to one, two, or three bouts of exercise running daily working up to running six miles daily, three days a week. The fourth group was a no exercise control group. At the end of 10 weeks, there was a comparable increase in oxygen uptake for all three exercise groups and only the group that split the exercise three times daily had an increase in HDL cholesterol.

In 1990, DeBusk and colleagues published a study comparing training effects of long versus short bouts of exercise where a single long was 30 minutes of vigorous exercise compared with three 10 minutes bouts at an equivalent intensity for five days of the week over an eight week period.[7] Maximal oxygen uptake increased in both groups but the group that did 30 minutes of continuous exercise had a greater increase than the short bout group. However, results were equivalent in treadmill test duration, decreases in heart rate, and slight decreases in weight.

Since the time of these early studies indicating that CVD risk factors could be improved by accumulating activity, other studies have been published. A recent review of 16 studies found that there is little difference between improvements in cardiovascular fitness with accumulated activity compared with continuous activity.[9] Similarly there appears to be no difference between short and long bouts for normalization of blood pressure. For other outcomes such as adiposity and improving blood lipids, the evidence is more equivocal and more studies are needed to determine if accumulated activity can be as effective as continuous exercise.

The studies of accumulated activity have played an important role in changing thinking about making exercise more convenient for sedentary populations since lack of time as frequently cited as a major barrier to adopting and maintaining regular physical activity.

Home-based versus Group Based Physical Activity Interventions

The fourth and final line of research that played a major role in the evolution of lifestyle physical activity interventions were studies that used theoretically based behavioral

interventions37-41 and in particular the studies that examined exercise in a home-based setting versus a group-based setting.8,42 Dr. King and colleagues randomly assigned 160 women and 197 men to one of three exercise training conditions: 1) higher intensity group-based training; 2) higher intensity home-based training; 3) lower intensity home-based training; or 4) assessment only control. For all three exercise conditions, the researchers found that exercise test performance was improved at 6 and 12 months and that adherence was better for the home based training programs at 12 months. The notion that individuals could perform exercise in a home setting and still maintain relatively high adherence levels was novel and an important precursor to the development of lifestyle physical activity programs.

These epidemiology studies and early experimental studies demonstrated that physical activity played an important role in preventing morbidity and mortality from CVD. They also demonstrated that physical inactivity was a risk factor for CVD with similar risk to already established risk factors such as smoking, high blood pressure and high cholesterol. The early experimental studies from the obesity literature and the accumulation of exercise demonstrated that fitness effects could be achieved by accumulating moderate intensity physical activity and that some CVD risk factors such as reducing weight, reducing blood pressure might be improved by accumulating moderate to vigorous physical activity. Finally, the behavioral interventions and especially those that used a home-based approach found that exercise could be done in a home based setting and one could maintain relatively high adherence rates. These studies all played a major role in changing thinking about whether exercise needed to be performed in a structured setting and that many types of physical activity could play a role in improving CVD outcomes. They also set the stage for efficacy studies of lifestyle physical activity.

III. Early Efficacy Studies of Lifestyle Physical Activity

There were several notable randomized controlled trials published in the 1990s that tested the efficacy of lifestyle interventions on various primary and secondary CVD outcomes. These included studies by Andersen and colleagues who examined the effects of a combined diet plus structured exercise program compared with a diet plus lifestyle physical activity program over a 16 week period with a one year follow-up.[43] Participants were forty obese women. At 16 weeks there was an equivalent amount of weight lost between the two groups (approximately 8 kg) and there were improvements in other risk factors for CVD including both LDL and HDL cholesterol, systolic blood pressure and maximal oxygen consumption. One year later, there were still improvements in systolic blood pressure and fitness and there was no difference in weight regain between the two groups.

One lifestyle study with a four-year follow-up was the Treatment of Mild Hypertension Study (TOMHS) (n=902).[44] This study tested a multi-risk factor intervention that included a nutrition intervention to reduce calories, fat, sodium and alcohol and also to increase home-based physical activity by 600 kcal per week. Participants were randomized to receive a placebo medication for blood pressure or one of five hypertensive medications and all participated in the lifestyle program. Participants were able to change lifestyle variables including weight, reduced 5.6% during the first year. Weight was still 3.0% lower at the four year follow-up. Similarly changes in sodium went from a reduction of 23% to 9% over the four year period and physical activity increase by 86% at year one and remained at 50% above baseline at year four. Changes in blood pressure were associated with changes in these lifestyle factors.

The effects of maintaining lifestyle changes was also demonstrated in the Project Active study, a randomized trial (n=235) that compared a behaviorally based lifestyle physical activity intervention compared to a structured exercise intervention.[1] Both groups received an intensive intervention over a 6 month period and an 18-month follow-up. In the lifestyle group,

participants met in a small group one time per week and were asked to engage in weekly home assignments designed to increase behavioral skills for physical activity. Behavioral skill building was based on the Transtheoretical Model (TTM) and Social Cognitive Theory (SCT) and included activities such as substituting physical activity for sedentary behaviors, learning how to set sequential goals to learn how to adopt and maintain physical activity. In the structured group, participants received a 6 month membership to a state-of-the-art fitness center, met with a personal trainer who helped them start an exercise program, to log their exercise, and to gradually increase their exercise. At 24 months there were significant improvements in physical activity, cardiorespiratory fitness, systolic and diastolic blood pressure, and body composition. These improvements were even greater in individuals who maintained their physical activity over 24 months to meet recommendations for moderate intensity physical activity of at least 150 minutes per week. In the lifestyle group, 39% met these recommendations 70% or more of the time and in the structured group, 35% reported they were meeting these recommendations 70% or more of the time. Another 29% and 24% of lifestyle and structured participants, respectively, reported meeting the recommendations between 40 to 60% of the time and the remainder (32% of lifestyle and 40% of structured) met the recommendations less than 30% of the time. Improvements in physical activity, blood pressure, and cholesterol were much greater for those who maintained 70% or more of the time compared with those who maintained less that 30% of the time.

These efficacy studies demonstrated that lifestyle physical activity and lifestyle interventions could improve cardiovascular risk factors including physical inactivity, blood pressure, body composition, and cardiorespiratory fitness. More importantly, changes in lifestyle behaviors were able to be maintained by a large percentage of those enrolled in the programs and long-term results suggest maintenance of physical activity and diet was accomplished by one-third to one-half of participants and, maintenance of lifestyle improvements in physical activity. The next challenge for researchers and practitioners was then to begin to implement these programs in other populations, e.g., individuals at high risk of developing diabetes, and age groups and to see if they could be delivered more widely by use of print materials, telephone, or the Internet.

IV. Effectiveness and Translational Studies

Since the early efficacy studies a substantial number of lifestyle effectiveness and translational research has been published and these have combined physical activity and diet to improve CVD outcomes. These effectiveness and translational studies also demonstrate improvements in CVD risk factors and evidence indicates that lifestyle interventions can be delivered in a variety of settings such as clinics, worksites, community settings and homes. In addition, it also appears that lifestyle interventions once delivered face-to-face can be delivered through a variety of media including print, Internet, and telephone.45 For example, in clinic settings, effectiveness trials like the Diabetes Prevention Project (DPP), a four-year study of more than 3200 overweight or obese individuals at risk for developing diabetes tested the effects of a lifestyle intervention, metformin prescription, or placebo control to prevent development of type 2 diabetes.[46] The lifestyle intervention targeted increasing physical activity to 150 minutes or more each week and reducing weight by 7%. The lifestyle intervention prevented development of type 2 diabetes in 58% of those individuals compared to placebo and was also more effective than metformin. Similarly the PREMIER trial of 810 adults with above average blood pressure found that a lifestyle intervention combining physical activity with the DASH (Dietary Approaches to Stop Hypertension) diet could significantly improve blood pressure to optimal levels compared with individuals who only received physician advice only.47

Some of these effectiveness studies have now undergone Phase II translational efforts, going from clinical trials into real world settings that are more generalizable, and this is due, in large part, to increasing translational efforts of the National Institutes of Health (NIH) and special

program announcements such at PAR-06-457, “Translational Research for the Prevention and Control of Diabetes and Obesity (R18)”. An exemplar of translational efforts has been the DPP study now translated into cardiac rehabilitation programs,[48] hospital-based weight loss programs,49 medically underserved neighborhoods,50 churches,51 and worksites.[52] Most of these translational studies resulted in weight loss,[48-50] improvements in fasting blood glucose,[51,52] and improvements in fitness or exercise[48,52] and demonstrated short-term sustainability of six months to one year. These efforts demonstrate translational efforts can be accomplished but not the issue becomes one of expanding their use.

Many interventions remain unused or underused by the target populations for whom they were developed. Green has written extensively on the necessity of better understanding of the relationship between a randomized clinical trial and what represents “best” practice in clinical settings 53,54 and more research is needed on better theoretical and practical understanding of why efficacious or effective interventions are not translated into practice. Theoretical models such as Diffusion of Innovations55 and RE-AIM[56] (Reach, Efficacy or Effectiveness, Adoption, Implementation, Maintenance) represent important theoretical models to study how to more widely implement many of the lifestyle interventions that seem to be unused or underused.[57] Similarly, it is also important to bridge the gap between research and practice and this is likely to mean gaining a better understanding about what users, practitioners and organizations think when they are asked to implement a program with demonstrated effectiveness. In addition, it is also important to build capacity including reaching out to advocacy groups, marketing firms, and taking advantage of technological innovations.58

VI. Dissemination and the Future of Lifestyle Physical Activity Interventions

Technological innovations represent promising avenues to reach large numbers of people and to effectively target lifestyle interventions to reduce risk. Technological innovations are being tested through use of mediated interventions that use print, telephone or the Internet or combinations of these. Several studies have now demonstrated the effectiveness of print and telephone interventions59[-63] that target improving physical activity behavior and other CVD risk factors. A recent review of 26 lifestyle interventions that targeted physical activity, diet or both in mostly middle-age or older adults and delivered by telephone found that outcomes were improved in most studies with a moderate effect size (0.60).[64]

Physical activity interventions targeting lifestyle behaviors and delivered via the Internet have now been tested with many patient populations including patients with type II diabetes[65-67] obese and overweight adults[68-71] and adults with disabilities[72] and in a variety of setting including primary care physician offices,[73] worksites[74,75] and churches.[76] Mostly Internet physical activity interventions have been tested in sedentary adults[77-80] and findings have been promising, though not universally positive. In a review published in 2007,Vandelanotte found improvements in physical activity outcomes in 8 out of 15 studies with effect sizes ranging from 0.13 to 0.67 and a mean effect size of 0.44.[81] Several theoretically based Internet physical activity interventions have been published since this review[74,76,78,82] and these have found modest improvements in physical activity but much less is known about improvements in other CVD risk factors.

The potential of mediated lifestyle interventions to reach large numbers of individuals seems promising but much more needs to be understood about what types of individuals respond best to different types of interventions.[83,84] In addition, many of these studies have only examined short-term outcomes and much more research needs to be done understanding who will maintains these lifestyle behaviors and who might need additional assistance and of what type.[85] It seems highly likely that lifestyle interventions that work for certain populations during the adoption phase may not have the same impact when individuals try to maintain regular

physical activity or as individuals develop from childhood onward.[86] What is also apparent when reading the details of mediated interventions is that often additional implementation strategies are needed to entice potential users or to get them to continue to use the materials since use of materials has been found to be correlated with improvements in risk.[87,88]

What we now know is that lifestyle interventions can be effective in reducing CVD risk in a wide variety of setting in with populations at risk of developing CVD or populations in secondary prevention programs. It is now important to reach across a variety of disciplines to better understand how we might effectively begin to address organizational, policy and political barriers and build the needed capacity to implement and market these interventions so they are most useful to those who need them.

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