REVIEW ARTICLE

Physical Activity Efficacy and Effectiveness Among Older Adults and Minorities

DANIEL O. CLARK, PHD

The objective of this study was to consider efficacy and effectiveness of physical activity for the prevention and management of NIDDM among minorities and older adults of the U.S. Relevant population trends and projections are discussed, followed by a review of the efficacy of physical activity based on theoretical, prospective cohort, and intervention studies. With few empirical studies available, the assessment of effectiveness is largely theoretical and focuses on potentially important issues for future studies among older adults and minorities. Efficacy studies have shown that moderate-intensity physical activity is associated with a one- to two-thirds lower incidence of NIDDM over 4–14 years and 15–20% lower glycosylated hemoglobin over 3–4 months among people with NIDDM. With physical inactivity prevalence at 60–70%, much work remains to be done to improve physical activity effectiveness. In the most vulnerable populations, physician referral and community involvement structured around stage of change and self-efficacy theories are suggested as the most promising approaches to promoting physical activity adoption and maintenance. Effectiveness or demonstration studies that test and build on stage of change, self-efficacy, and other concepts of physical activity promotion and outcomes would likely prove to be highly valuable investments for public health.

Of adults over age 45 residing in the U.S., 8% has diagnosed NIDDM and an additional 20% has either undiagnosed NIDDM or impaired glucose tolerance (IGT) (1). Among minority adults in the U.S., the rates are even higher. Playing a role in over 150,000 deaths per year, diabetes is the seventh underlying cause of death in the U.S. (2). The causes of NIDDM and its complications are numerous and complex, but physical inactivity is an important factor. With a prevalence of at least 60% (3), physical inactivity is among the top three leading actual causes of death in the U.S. (4) and is estimated to cause 250,000 deaths per year (5). The proportion of the risk of diabetes attributable to physical inactivity has been estimated at 24% (6). Clearly, physical inactivity has considerable public health and clinical significance.

Topics of study in the fields of public health and clinical medicine tend to evolve along a continuum from efficacy to effectiveness and efficiency studies (7). Efficacy studies address how well an intervention can work in an ideal or controlled context and effectiveness studies address how well an intervention actually works in the "real world." Efficiency studies address issues related to resources and valuation (e.g., cost-benefit or cost-effectiveness) (7). Theoretical, descriptive epidemiology, and intervention studies are all valuable in determining efficacy, while intervention studies and demonstration programs are most commonly used in assessing effectiveness.

A considerable number of studies have addressed physical activity efficacy in NIDDM prevention and management, but few have addressed effectiveness or efficiency. In this article, theoretical, prospective cohort, and intervention studies relevant to the determination of the efficacy of physical activity for NIDDM primary prevention and management (i.e., tertiary prevention) are reviewed. This is followed by a discussion of theoretical issues of importance to future assessments of physical activity effectiveness and a review of a few intervention studies with clear relevance to assessments of effectiveness. Because of the high prevalence of physical inactivity, NIDDM, and NIDDM-related complications among older adults and minorities (8,9), this article places particular emphasis on approaches to optimizing and assessing effectiveness within these special populations. Accordingly, the review begins with a discussion of estimates and projections for the proportion of the U.S. population that is either aged or minority, as well as estimates of obesity and physical inactivity.

POPULATION TRENDS AND PROJECTIONS

— The prevalence of diagnosed and undiagnosed NIDDM is positively associated with age and minority status. Prevalence among people over the age of 65 years is eight times greater than the prevalence among people 20–44 years of age (1), and minority ethnic populations experience from two to six times greater prevalence than members of the majority ethnic population of the U.S. (8). As Table 1 shows, both the aged and minority segments of the population have increased and are projected to increase faster than the population as a whole. Within the minority population, rates of NIDDM are 25% higher among Hispanics in comparison to blacks (1), and Hispanics are the largest and fastest-growing minority group (10). Without a decrease in the prevalence of NIDDM among the rapidly growing older adult and minority populations in the coming 3 decades, the number of people in the U.S. with NIDDM will increase at a faster rate than the population as a whole, which is projected to increase 40% between 1990 and 2030.

Unfortunately, recent trends in and current rates of obesity and physical inactivity are not favorable to primary prevention of NIDDM (Table 1). Obesity has increased in the last 2 decades (11), even as dietary quality has improved (12). Obesity estimates are 30–35% for the population as a whole (11) but estimates for some groups (e.g., African-American women) are as high as 80% (13). Of even greater concern, the

From the Department of Medicine and Regenstrief Institute for Health Care, Indiana University School of Medicine, Indianapolis, Indiana.

Address correspondence and reprint requests to Daniel O. Clark, PhD, Indiana University School of Medicine, Regenstrief Institute for Health Care, 1001 West Tenth St., RG-6, Indianapolis, IN 46202-2859. E-mail: clark_d@regenstrief.iupui.edu.

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DPP, Diabetes Prevention Program; IGT, impaired glucose tolerance; PACE, Physician-based Assessment and Counseling for Physical Activity; PAR-Q, Physical Activity Readiness Questionnaire.

Table 1—*Population trends and projections and obesity and physical activity estimates*

	1970	1980	1990	2000	2030
Total population (in millions)	203	227	249	276	350
Percent ≥45 years of age	30.3	30.8	30.9	34.4	40.8
Percent ≥65 years of age	9.8	11.3	12.5	12.8	20.1
Median age	28.0	30.0	32.8	35.7	38.0
Percent minority	12.3	14.0	16.1	17.8	21.4
Percent obese	25.0	25.4	33.3	—	—
Percent underactive	—	—	60.0	—	—

Population projections are based on U.S. Bureau of the Census middle series projections. (2,10,11)

increase in obesity has shown no sign of decline among any adult population of the U.S. (14). Generalizable data on physical inactivity are unavailable before the mid 1980s, but recent estimates indicate that at least 60% of the adult population of the U.S. does not meet even the recommended minimum levels of physical activity (3). Physical inactivity is higher among people over 45 years of age, non–college graduates, and minorities (9,14,15). People with diabetes are slightly more likely to be physically inactive than people without (66 vs. 59%, respectively), but this difference is eliminated when activity limitations are taken into consideration (16).

EFFICACY — Efficacy is assessed by considering theoretical mechanisms linking bodily movement of large skeletal muscles (i.e., physical activity) to NIDDM prevention and management as well as findings from intervention and observational studies. Observational (prospective cohort) studies are briefly noted primarily to consider efficacy for prevention of NIDDM, while intervention studies are available to consider efficacy for NIDDM management.

Physical activity can improve overall metabolic control, independent of weight or weight loss (17), and improved metabolic control may lead to fewer NIDDM complications and greater longevity (18). Improved metabolic control occurs within days or even hours of physical activity (19). The mechanisms responsible for increased glucose uptake and insulin sensitivity in response to bodily movement are complex, but, theoretically, increased muscle activity produces an increase in muscle blood flow, which leads to increased glucose and insulin delivery to the muscle. Next, muscle contraction results in an increase in membrane permeability to glucose, which may be facilitated by an increase in the insulin sensitivity of the muscle (17). Importantly, this increased permeability can last for many hours after the cessation of muscle contraction and works in an additive fashion with insulin. Perseghin et al. (20) recently showed that physical activity performed at 55–70% of maximal heart rate four times per week for 6 weeks led to increased insulin sensitivity through a twofold increase in insulin-stimulated glycogen synthesis in muscle, which was due to an increase in insulin-stimulated glucose transport phosphorylation. This process was apparent among people with and without NIDDM.

NIDDM prevention

Observational studies have consistently supported theoretically expected associations between physical activity and NIDDM prevention (21–23). Prospective cohort studies have shown that the incidence of NIDDM is one- to two-thirds lower among those who report regular physical activity (5,24–27). These observational studies occurred over 2–14 years of follow-up and relied on self-reported physical activity levels, making estimates of dose response imprecise. Nonetheless, several studies have documented an expected pattern of decreased incidence with greater physical activity (24,26,27).

There are many limitations to these observational studies, so the controlled randomized trial that was initiated in June of 1996 by the National Institute of Diabetes and Digestive and Kidney Diseases would provide important data. The Diabetes Prevention Program (DPP) will recruit subjects with impaired glucose tolerance, with the added stipulation that 50% of the subjects be of minority ethnic status; ~20% will be 65 years of age or over. One of the intervention arms of the DPP is an intensive lifestyle intervention that will attempt to achieve a 7% weight reduction through monitored caloric intake and an increase in calorie expenditure through moderate physical activity. The primary outcome of the study will be development of NIDDM. The results will be invaluable to assessments of the efficacy of lifestyle alterations (i.e., diet and physical activity) for NIDDM prevention.

NIDDM management

Intervention studies have shown that physical activity plays an important role in glucose tolerance and insulin sensitivity both with and without weight loss (20,27–36). One study demonstrated a 36% reduction in plasma glucose concentration in an oral glucose tolerance test after 1 week of intense physical activity among seven men with mild NIDDM and three men with IGT (no changes in weight occurred over this 1-week period) (19). Another study demonstrated a 15% drop in HbA_{1c} among 20 men with NIDDM after just 6 weeks of moderate-intensity physical activity three times per week, 30 min each session (35). Stuart (37) showed a significant reduction in HbA_{1c} after 12 weeks of moderate-intensity physical activity performed three times per week among five women with NIDDM. One study with a relatively long intervention and follow-up among African-American women consisted of 18 weeks of once-a-week diet and physical activity instruction among 10 obese women with NIDDM (38). At 18 weeks, HbA_{1c} was down from 12.8 to 10.2. By the 1-year follow-up, however, mean HbA_{1c} was back to its baseline level (12.6).

Intervention studies with longer follow-ups have been few, and the few have generally included both physical activity and diet in the intervention. At least one study of aerobic exercise alone did not find long-term improvements in glycemic control, but another study of resistance exercise alone showed a 10% improvement in HbA_{1c} (39). Kaplan et al. (32) showed a 16% drop in HbA_{1c} (9.2 to 7.7) over an 18-month diet with a moderate-intensity physical activity intervention program among 70 NIDDM volunteers recruited from San Diego County (no changes in weight occurred). Another study consisting of 6 months of supervised diet and physical activity training led to significant improvements in glucose tolerance at the 5-year follow-up among 41 Swedish men with mild NIDDM at baseline (28). Of these 41 subjects, 44% no longer reached glucose levels

diagnostic for diabetes at the 5-year follow-up. On the whole, these studies support the efficacy of physical activity for the prevention of NIDDM and the management of glucose concentration among those with NIDDM.

Comorbidity

Comorbidity, including obesity, plays a central role in complications of NIDDM. Cardiovascular disease, for example, is the leading cause of mortality among people with NIDDM (40), and patients with both diabetes and hypertension are at particularly high risk for coronary artery disease (41). Physical activity plays a primary role in the prevention of cardiovascular disease. In one recently published study, previously sedentary men who adopted regular physical activity during a 4-year period experienced risk reductions of 44% for all-cause mortality and 52% for cardiovascular mortality during a subsequent 5-year period (42). Physical activity has also been shown to have a direct impact on the management of hypertension (43). Although no studies of the effect of physical activity on NIDDM complication rates were identified, one study showed that macrovascular complications were inversely associated with historical physical activity among men 22–48 years of age who had been diagnosed previously with IDDM (44).

Thus, although much more NIDDM-specific research is needed, the efficacy of physical activity in the management and prevention of comorbidity is promising. Under less than ideal compliance, the reviewed intervention studies showed improvements of 15–20% in glycosylated hemoglobin over 3–4 months of intervention. Studies over longer periods are difficult to judge because of limited control and multifaceted interventions. Prospective cohort analyses must be used to judge efficacy for prevention and, given error in self-reported physical activity and poor control, these are likely to underestimate efficacy. Nonetheless, prospective cohort studies have shown incidence to be one- to two-thirds lower among those reporting regular physical activity in comparison to those reporting no physical activity.

EFFECTIVENESS — There were no studies of physical activity effectiveness identified, either for NIDDM prevention or management. For a study to be capable of providing effectiveness estimates, it must draw a representative sample from a defined population. People who refuse to engage in the intervention, drop out, or have poor compliance must all be included in the final analyses. Even among adults in general, studies have relied on very select samples, and there may not be any true physical activity effectiveness studies. One recent physical activity study consisted of a random sample of adults aged 65 years and over who were Medicare beneficiaries (45), but just 4% of the original sample participated in the study. Although this was not billed as an effectiveness study per se, the low rate of final participation suggests that the effectiveness of this particular program would be very low. The most representative study of physical activity to date included just 11% of the target population (46).

More inclusive programs and studies are possible. The American College of Sports Medicine provides detailed recommendations for physical activity testing and prescription. Although exercise testing is recommended among people with known chronic disease, including NIDDM, virtually all sedentary individuals can begin a moderate-intensity physical activity program safely (47). People with NIDDM who are treated with insulin or sulfonylureas must pay close attention to hypoglycemia, foot care, and, for those with autonomic neuropathy, hypertension during and hypotension immediately after physical activity. Nonetheless, with proper testing and self-monitoring, the effectiveness of different programs of physical activity promotion can be assessed among populations representative of the diversity of older adults and minorities.

ADOPTION AND MAINTENANCE — In considering theoretical approaches to increased physical activity participation, it is important to note that adoption and maintenance are separate outcomes and deserve separate attention in designing interventions. Adoption signifies the initiation of a behavior and generally follows a period of thought or contemplation. Maintenance represents the successful management of factors affecting (positively or negatively) the continued performance of a behavior (i.e., habituation). Factors thought to affect physical activity adoption and maintenance fit well within two complementary theoretical frameworks: the stages of change theory (or transtheoretical model) (48) and self-efficacy theory (49). The stages of change theory states that people are at different cognitive and performance levels with regard to a particular behavior and that predictors of future behavior will vary across those levels. The goal is not to move people from inactive to active, for example, but to move people up the ladder to the next stage. Strategies for moving people up the ladder depend on the particular stage that currently characterizes the individual. The stages of change were originally developed to improve understanding of smoking cessation, but have since been applied to a range of behaviors, including physical activity. There are five stages of readiness for change: precontemplation, contemplation, preparation, action (i.e., adoption), and maintenance.

The self-efficacy theory fits well within the stages of change theory and consists of two primary components: efficacy expectations and outcome expectations (49). Efficacy expectations are defined as "judgments of one's capability to accomplish a certain level of performance." Outcome expectations form an integral part of self-efficacy theory and represent "judgments of the likely consequence a behavior will produce," according to Bandura (49). Thus, efficacy expectations represent judgments of personal competence, while outcome expectations represent judgments of the likely impact of a given behavior (50). Self-efficacy theory has shown the greatest promise for explaining physical activity adoption among adult populations (51–53).

Despite recognition of the prominent role of self-efficacy in behavior modification, little empirical information is available to determine just what factors affect self-efficacy (54). Theoretically, efficacy expectations develop through four types of influence: primary experiences, secondary experiences, verbal persuasion, and physiological states (55). Primary experiences with the behavior in question (i.e., physical activity) are generally considered most influential. Empirical studies support this by demonstrating that people with previous physical activity experience (9), and particularly previous success (51), have substantially higher efficacy expectations. Secondary experiences represent observations of others' physical activity experiences. This is particularly effective in the form of modeling (e.g., someone similar to the individual overcomes difficulty and experiences success). Secondary experiences may come from many sources, including family, peers, professionals, and all forms of media presentation. Similarly, verbal persua-

sion comes from many sources, but usually comes from supportive others, including health care professionals and family and can come from media presentations. Finally, physiological states represent current feelings and sensations (e.g., aches, pains, nervousness). Although Bandura (49) characterizes these four influences as ways of facilitating efficacy expectations, each also may represent a barrier to greater efficacy expectations. Thus, each of the four sources of influence (i.e., primary and secondary experiences, verbal persuasion, and physiological states) may comprise either or both facilitators of and barriers to improved efficacy expectations. The barriers and facilitators that contribute to each source of influence will be unique for each individual, but sociodemographic characteristics and social and physical contexts affect the probability that certain barriers or facilitators are present and others absent (50).

No generalizable studies of stage of physical activity among older adults, minorities, or people with NIDDM were identified. There is also very little published regarding barriers and facilitators of efficacy and outcome expectations or, more generally, physical activity adoption and maintenance.

Physician counseling

In an implicit application of the self-efficacy theory, physician-initiated physical activity counseling has been highly recommended of late for physical activity promotion (56–60). By using verbal persuasion, this approach closely follows the recommendations of the self-efficacy theory. Unfortunately, protocols for physician-initiated physical activity counseling have rarely been tested. The Physician-based Assessment and Counseling for Physical Activity (PACE) study began with the development of a protocol and then proceeded to the implementation and assessment of the protocol at four sites around the U.S. (61). The protocol involved the recruitment and training of primary care physicians who had volunteered and expressed interest in counseling for physical activity. Physicians received 1–2 h of training in the use of a physician's manual, a PACE assessment form, the Physical Activity Readiness Questionnaire (PAR-Q) (a short battery of questions to identify patients who might be at risk from large increases in physical activity) (62), and separate counseling protocols for people in the precontemplation, contemplation, and action or maintenance stages of physical activity. While waiting to see a provider, patients were asked to complete the PAR-Q and a questionnaire that would determine their stages of readiness for change. The physician used the information from the questionnaires to determine which counseling protocol was appropriate. The counseling and assessment generally took ~5 min of the physician's time. Direct measures of effectiveness of the counseling were not taken, but 4 out of 6 precontemplators reported thinking about physical activity more, 31 out of 47 contemplators reported increased physical activity, and 35 out of 45 "actives" reported maintained or increased activity levels.

One other study of the effect of physician counseling for physical activity was actually much less intensive but apparently more effective. The intervention consisted of 15 min of training of family physicians on the use of a 3-min relatively structured protocol for physical activity advice (63). Of the patients visiting physicians in the experimental group, 80% received advice for physical activity, versus 40% of the patients seeing physicians in the control group. After intervention, 18% of the patients seeing experimental group physicians reported regular physical activity, while just 6% of patients seeing control group physicians reported regular physical activity.

While the physicians reported satisfaction and compliance with both the PACE and Lewis and Lynch protocols, concerns from the physicians regarding lack of time and staff support for physical activity counseling were not changed. Along with lack of reimbursement and lack of skill and confidence in counseling for behavior modification, these are the most common concerns voiced by physicians regarding physical activity counseling (64–68). Lack of time and support staff had considerable impact on the implementation of the protocol in the PACE study. In fact, "if the staff did not ensure that assessment and counseling forms were completed and in the chart prior to the provider interaction, the provider often did not remember to conduct counseling," according to Long et al. (61).

Community participation

Physician or clinic counseling in isolation from other resources is not likely to be the most effective approach to physical activity promotion, particularly among older adults and minorities. Integration with existing resources, such as churches and community organizations, may prove more effective. Over 90% of older African-American women, for example, "belong" to a church, and churches located in predominantly African-American neighborhoods recognize improved health as one of the greatest needs of African-American communities (69). The use of neighborhood resources (e.g., church, clinic, or school) in combination with the involvement of community leaders has been proven to elevate trust and support in health promotion programs (70–73). Comprehensive programs drawing upon resources of health clinics, churches, and city and neighborhood organizations may be most effective in promoting physical activity adoption and maintenance.

In summary, factors that have been theoretically or empirically identified as potentially influential to physical activity adoption and maintenance should be carefully operationalized and tested within well-designed demonstration studies. Physical inactivity may be the leading actual cause of death among older adults in the U.S. (74), but little is known about the effectiveness of physical activity or physical activity promotion programs.

CONCLUSIONS

— Theoretical, observational, and intervention studies indicate there is a strong efficacy for physical activity in NIDDM prevention and management. Under ideal physical activity levels (i.e., 30 min of moderate-intensity physical activity most days of the week), one in four NIDDM cases might be prevented (6). With just 10% of the adult population currently meeting this level of physical activity (3), the effectiveness of physical activity may be as little as one-tenth the efficacy. How much this can be improved is yet to be determined. In efficacy studies to date, physical activity maintenance beyond 3 months has generally been poor, and these studies have generally used presumably motivated volunteer subjects. The low maintenance may be due in part to designs that have failed to capitalize on theories of behavior modification and community empowerment, which have proven to be the most effective in behavior adoption and maintenance.

Effectiveness can only be maximized if all eligible people are the target of intervention and promotion strategies. To date, those least likely to be physically active have been the most likely to be excluded from studies. This can be justified in effi-

cacy studies but is counterproductive to many effectiveness objectives. To estimate and ultimately maximize effectiveness, physical activity programs designed to use, test, and refine theories of behavior modification, community empowerment, and health care provider involvement will be needed. The potential for prevention, improved management, and possibly cost reduction would seem to justify the effort and resources necessary to carry out such effectiveness studies.

Whether physical activity programs can be cost-effective is an issue of efficiency, and efficiency of physical activity and its promotion have not been directly studied. Two prospective cohort studies showed that physician visits and hospitalization were lower over 4- to 6-year periods among those who reported walking regularly at baseline (75,76). The reductions were ~10% per year and due largely to cardiovascular disease and events. Although some physical activity interventions have been rather expensive (77), there is evidence to suggest that much less expensive home-based interventions can produce similar outcomes (46). Some segments of the population are likely to engage in regular physical activity with very little resource input, while other segments will require considerable investment. How much of an investment can be made within an acceptable cost-benefit ratio is an issue of efficiency and one that can only be addressed after some work on effectiveness has been completed. In short, what proportion and segment of the population can and will perform physical activity, under what conditions, for how long, and at what savings has yet to be determined.

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